THE TECH ENGINEERING NEWS

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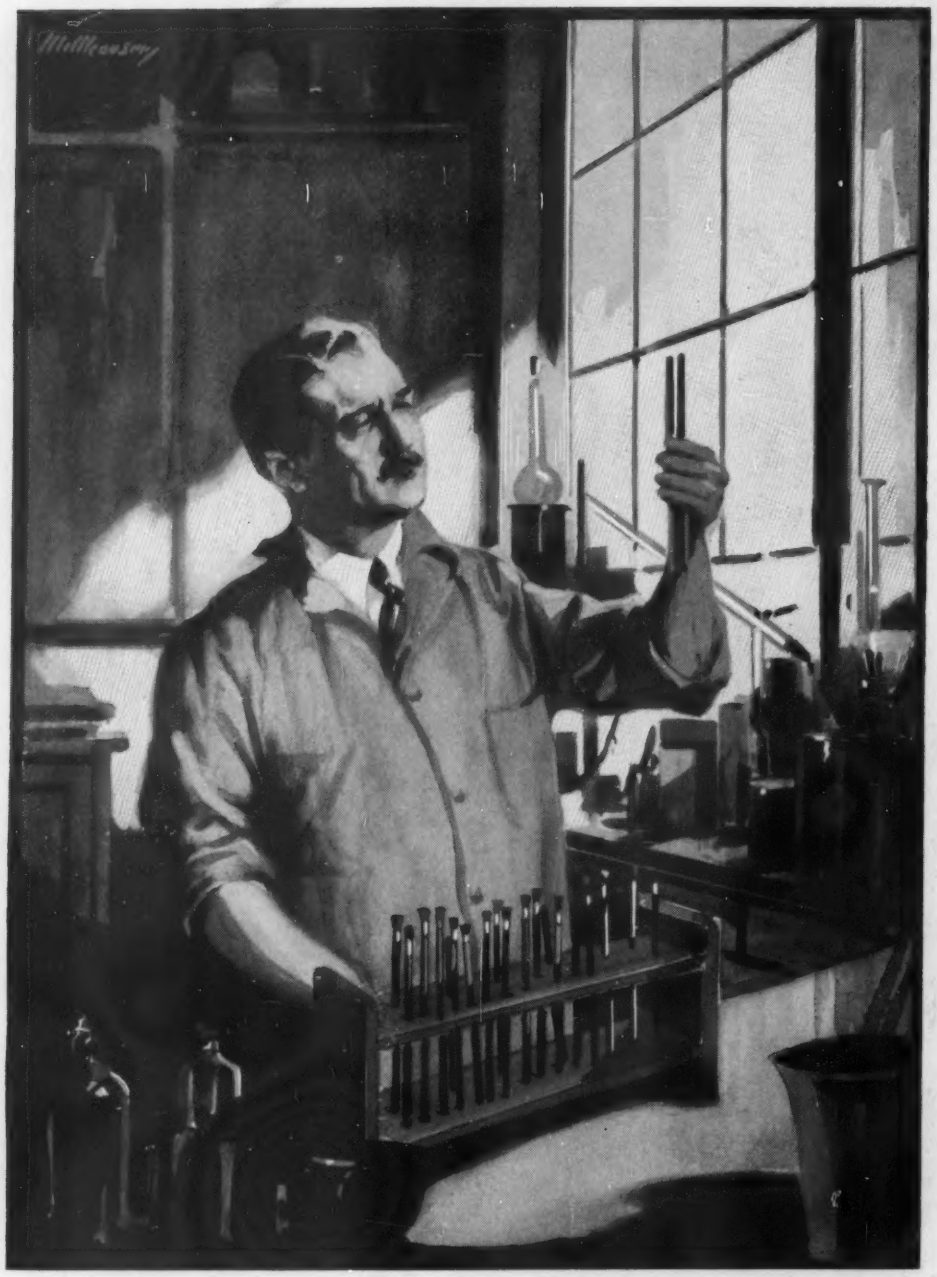

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The Tech Engineering News

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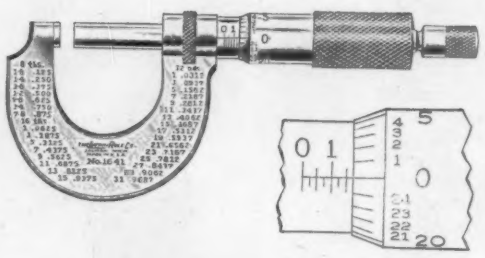

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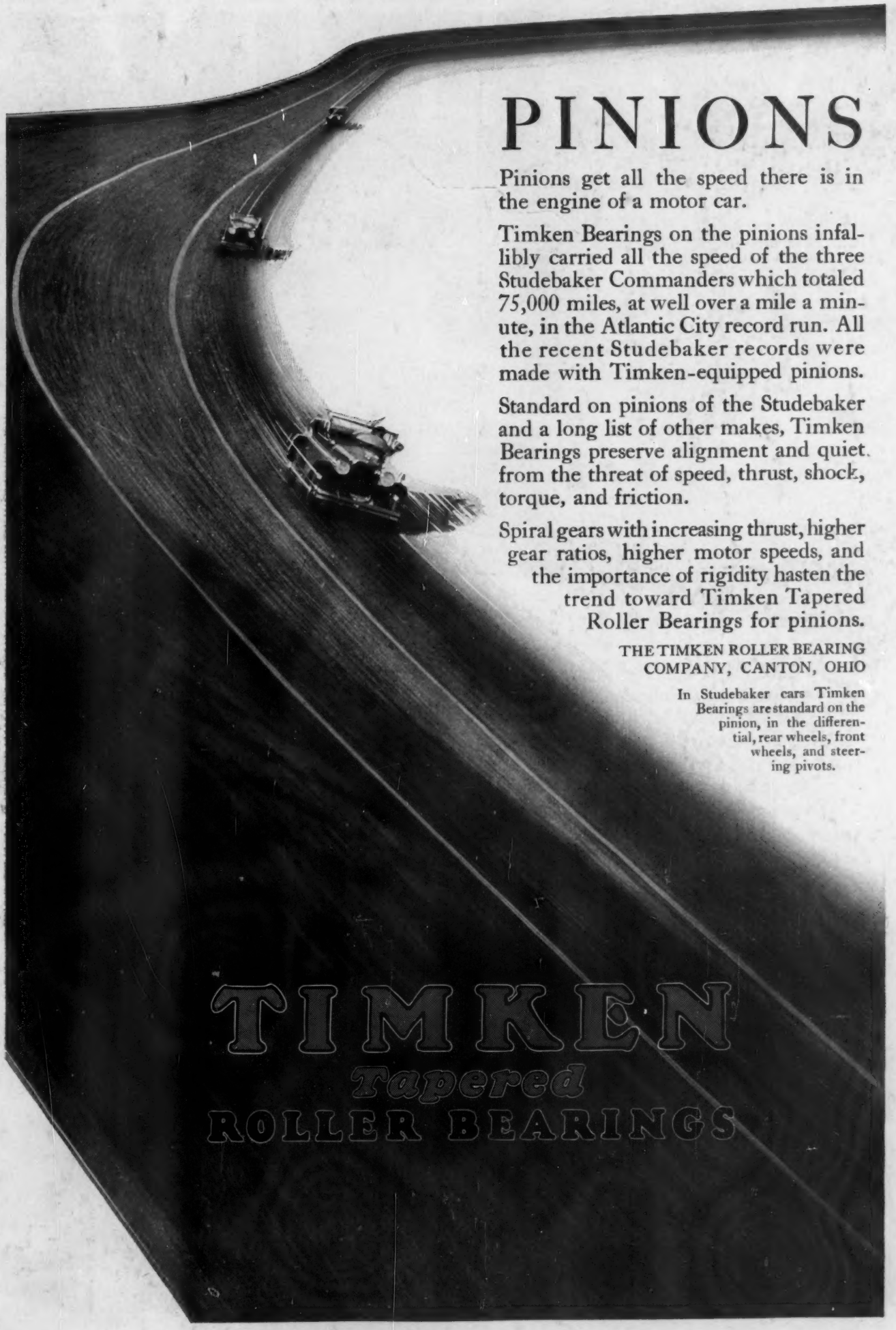

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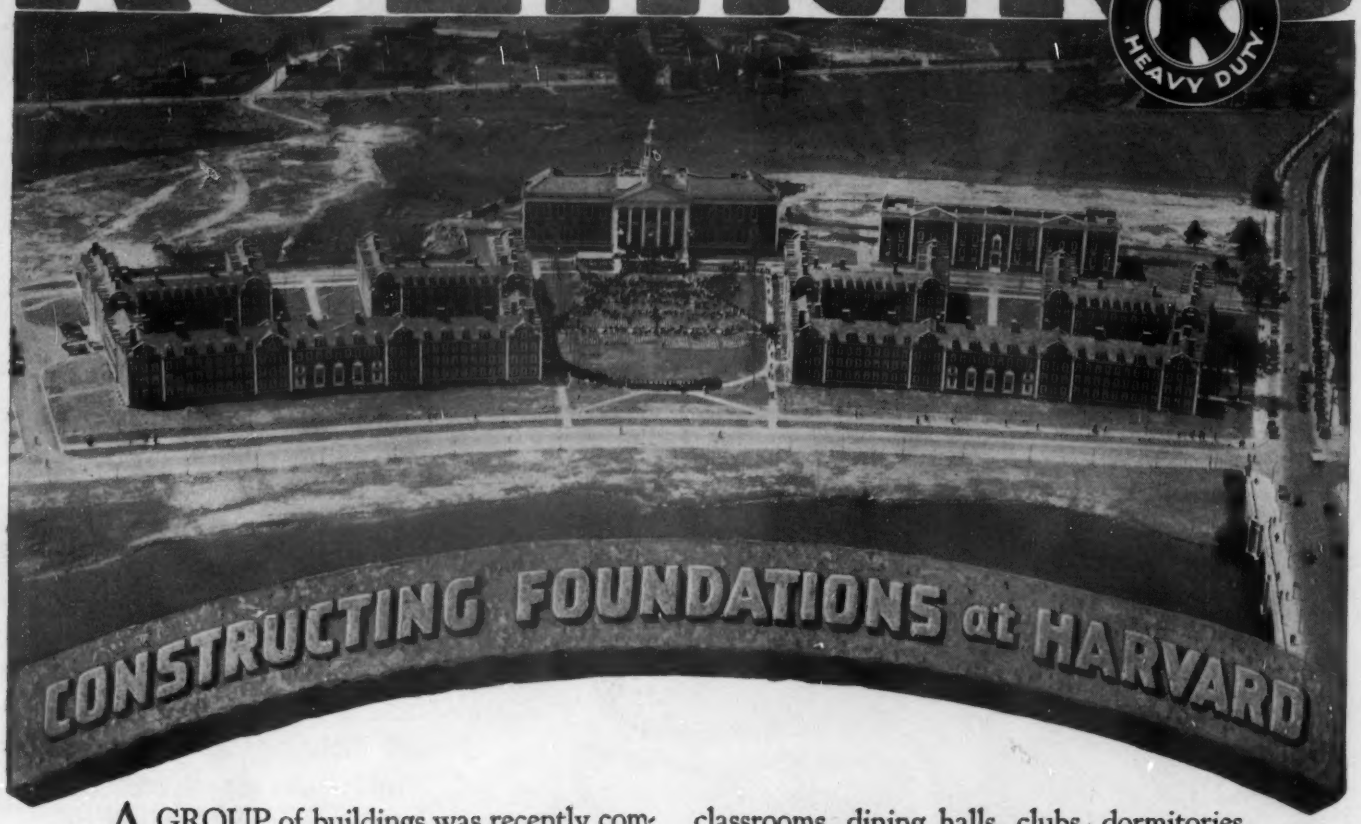

A GROUP of buildings was recently completed in Cambridge, Massachusetts, for the Graduate School of Business Administration, Harvard University. The group was planned as a unit and developed in accordance with a definite idea that buildings and grounds could and should help in education, and that personality could be brought out in an atmosphere of quiet and good taste appropriate to an old university.

Included in this modern school of business are specific buildings for adminstration, classrooms, dining halls, clubs, dormitories, library, recreation, business research, and professors homes. The total cost of all of these as illustrated in the above picture was approximately $5,000,000.

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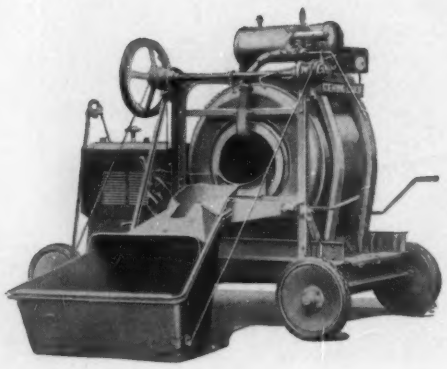

The revised edition of "Concrete — Its Manufacture and Use," a complete treatise and handbook on present methods of preparing and handling portland cement concrete, is now ready for distribution. To engineering students, faculty members and others interested we shall gladly send a copy on request.

THE TECH ENGINEERING NEWS

Volume IX — CAMBRIDGE, MASS., FEBRUARY, 1928 — Number 1

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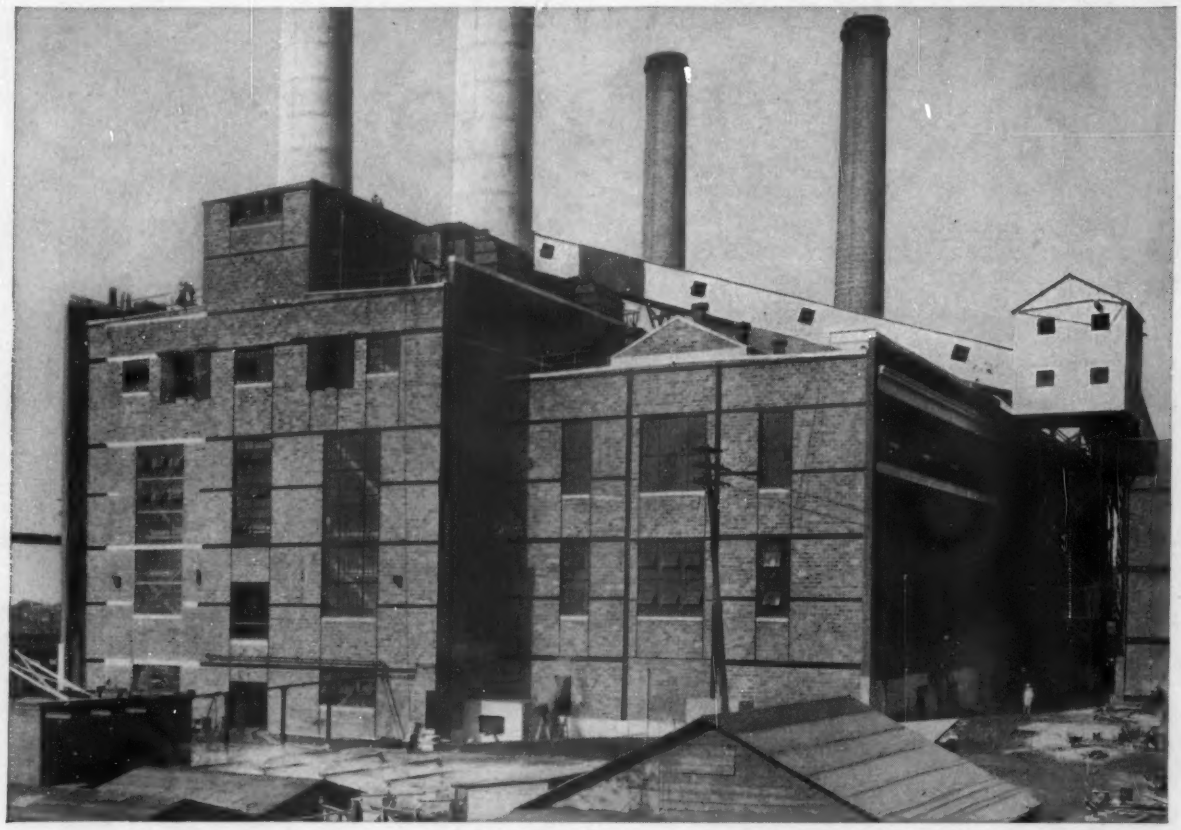

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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME IX | FEBRUARY, 1928 | NUMBER 1

Knowledge Plus Wisdom

A suggestion for a new course at Technology

By WILLIAM E. NICKERSON '76
Director of State Street Trust Company

I WOULD not be justified in writing as I propose to do, if I were not an old man and I may be presuming overmuch as it is. Hamlet told Polonius that he read that old men had gray beards. But, as you can see, this does not apply to me. In my case it would be quite inappropriate, as I am in the razor business. Further, that their faces were wrinkled, their eyes purging thick amber and plum tree gum and that they had most weak hams. These, I think, are only partially true of me. Worst of all; that they had a plentiful lack of wit. Of this latter I may succeed in convincing you before I have finished. Hamlet said he believed all these things of old men and spoke of Polonius as a tedious old fool. It may be that there are brilliant young gentlemen present, who, to a greater or less degree, share Hamlet's opinion. One of my favorite philosophers, Josh Billings, once said: "When i waz 20 i knew twice as mutch az i do now, and the way things are going on, if i should liv to be 75 i don't expekt to kno nothing." Nevertheless, I have a few things to say to you which may, or may not, interest you.

I do not know, of course, to what extent the distinction between Knowledge and Wisdom has entered your minds. Some of you may regard the terms as practically synonymous, others may sharply distinguish between them. According to Webster's New International Dictionary, Knowledge, in the sense I am discussing it, is that which is gained and preserved by knowing; enlightenment; learning; scholarship; erudition. Wisdom, by the same authority, is the ability to judge soundly and deal sagaciously with facts, especially as they relate to life and conduct; the capacity to make due use of Knowledge; perception of the best ends and the best means; discernment and judgment; discretion; sagacity. Landor has expressed the thought as follows: "Wisdom consisteth not in knowing many things, nor even in knowing them thoroughly; but in choosing and in following what conduces the most certainly to our lasting happiness and true glory." Cowper put the relationship of Knowledge and Wisdom into poetical form with great truth and effectiveness.

We are presenting this article to our readers so that the students and alumni of the Institute may give the question of a course in Humanics careful consideration. Mr. Nickerson has suggested a course which would greatly affect the personality of Technology men. THE TECH ENGINEERING NEWS *will welcome any comments on this plan and will publish them on its editorial page.*

Knowledge and Wisdom, far from being one,
Have ofttimes no connection. Knowledge dwells
In heads replete with thoughts of other men;
Wisdom, in minds attentive to their own.
Knowledge — a rude, unprofitable mass,
The mere materials with which Wisdom builds,
Till smoothed, and squared, and fitted to its place —
Does but encumber whom it seems to enrich.
Knowledge is proud that he has learned so much;
Wisdom is humble that he knows no more.

You may now wonder whether my address is to consist of an academic discussion concerning the meaning of words. That is not my intention. I have, however, an idea that a clear conception of the fundamental difference between Knowledge and Wisdom in the minds of students might perhaps lead to an improvement in the quality and an increase in the quantity of the latter virtue in those who think seriously on this subject.

Knowledge and Wisdom form a strong team when they pull together. Much Wisdom with little Knowledge may be somewhat weak, but often accomplishes quite remarkable things. Much Knowledge with little Wisdom may run amuck, or may prove quite ineffective. This might be compared to a ship loaded with valuable freight, but having no rudder and unreliable navigating instruments, she rolls about on the ocean, but gets nowhere.

In speaking of much Wisdom and relatively restricted Knowledge, I think of my own grandfather, whose schooling, according to our standards, was small, but who was very far from being ignorant. His life, up to forty, was one of severe exertion and hardship, but was crowned by measurable success, and brought a comfortable and respected old age, reaching to ninety years. Slow to promise but quick to perform, always thoughtful and far-seeing, never making an important decision until at least one night had passed, he looked at all important matters from every side and made very few mistakes. Old Cape Cod has produced many such men and some highly educated people have seemed weak and foolish by contrast. These were excellent examples of men whose success was due principally to innate Wisdom rather than to Knowledge, and it seems to me that if we cannot have Wisdom and Knowledge in liberal

measure working together, it is preferable to have predominant Wisdom rather than the reverse.

In contrast to the men of little learning and much practical Wisdom, consider the men of marvellous attainments. Those living encyclopedias who here and there grace their profession: in science; in the law; in medicine; in statecraft and in other activities that give opportunity to use great accumulations of Knowledge. We may feel when considering them somewhat like the rustic people contemplating the schoolmaster in Goldsmith's Deserted Village: "And still they gazed; and still the wonder grew; That one small head could carry all he knew." But we are bound to admit that they must have possessed a goodly share of Wisdom in addition to their great Knowledge, or they would hardly have succeeded in becoming great.

". . . Every other quality is subordinate and inferior to Wisdom, in the same sense as the mason who lays the bricks and stones in a building is inferior to the architect who drew the plan and superintends the work. The former executes only what the latter contrives and directs. Now, it is the prerogative of Wisdom to preside over every inferior principle, to regulate the exercise of every power, and limit the indulgence of every appetite, as shall best conduce to one great end. It being the province of Wisdom to preside, it sits as umpire on every difficulty, and so gives the final direction and control to all the powers of our nature. Hence it is entitled to be considered as the top and summit of perfection. It belongs to Wisdom to determine when to act and when to cease, when to reveal and when to conceal a matter — when to speak and when to keep silent — when to give and when to receive; in short, to regulate the measure of all things, as well as to determine the end, and provide the means of obtaining the end pursued in every deliberate course of action. Every particular faculty or skill, besides, needs to derive direction from this; they are all quite incapable of directing themselves. The art of navigation, for instance, will teach us to steer a ship across the ocean, but it will never teach us on what occasion it is proper to take a voyage. The art of war will instruct us how to marshal an army, or to fight a battle to the greatest advantage, but you must learn from a higher school when it is fitting, just, and proper to wage war or to make peace. The art of the husbandman is to sow and bring to maturity the precious fruits of the earth; it belongs to another skill to regulate their consumption, by a regard to our health, fortune, and other circumstances. In short, there is no faculty we can exert, no species of skill we can apply, but requires a superintending hand — but looks up, as it were, to some higher principle, as a maid to her mistress for direction; and this universal superintendent is Wisdom."

Universities and colleges and especially scientific schools, like the Massachusetts Institute of Technology, exist primarily for the purpose of affording opportunities to young men and young women to accumulate stores of Knowledge which are to be useful to them during life and by means of which, it is hoped, they will become citizens of great value to the country and to the world at large. You come here, young gentlemen, for Knowledge; to learn about chemical reactions and combinations; about strains and stresses; about many kinds of vibrations; about measurements of all sorts, from the wave lengths of Ultra-Violet light, to the distances of the far-away nebulae; and so on, almost to infinity. That is quite right. For what else would you come? Not for social distinction, surely. M. I. T. leaves that distinction to be sought at other institutions. Is it possible that something which is not Knowledge but is complementary to it, might be acquired here; in some degree at least?

WILLIAM E. NICKERSON '76

It is more than likely that some of my hearers may have thought that I was rather satirical in my opening paragraph, even to the point of sarcasm. That may be so. But I had an object in view. I wished to challenge your attention at the start; to arouse in your minds a little curiosity as to what I might say next. I am quite in earnest in what I am saying and I desire to carry you along with me. Above all, I desire not to be tedious, for I think I am really telling you something worth hearing.

It is natural and inevitable that a young man who comes here to learn should stress Knowledge. It is right that he should. He feels the need of Knowledge, and more Knowledge. He is likely to think that this is all he does need. He has not yet reached the stage where he realizes that something more is necessary, if he is to make the fullest use of the Knowledge he has gained. Knowledge to him is the great sun in the heavens and its dazzling light renders all else obscure. "Knowledge partakes of Infinity; it widens with our capacities: the higher we mount in it, the vaster and more magnificent are the prospects it stretches out before us." The old man, on the contrary, when he looks backward and recalls how often he has acted foolishly and how much he has lost, in time, in effort and in success, because of unwise procedure, is very likely to stress Knowledge less and exalt Wisdom proportionately. After a certain age our Knowledge may not as a whole increase, on account of our forgetting much that has been learned, as an offset to that which is being learned; but Wisdom may go on ripening up to the point of mental decay.

The problems of active life may be roughly divided into two classes. First, those relating to Nature and natural laws; and second, those having to do mainly with our fellow men. In dealing with the first, Knowledge is in the ascendant and a moderate amount of Wisdom may suffice; but in wrestling with the second class, while Knowledge is still necessary, full use will be found for all Wisdom that can possibly be brought to bear upon the task. The young man who enters the Institute has had at least ten years in the elementary and high schools in quest of Knowledge. Then another period of four years is given to the same pur-

(*Continued on page 21*)

The Hudson River Bridge

A sixty million dollar structure which is to be the largest of its kind

By O. H. AMMANN
Chief Engineer of Bridges
Port of New York Authority

THIS is an age of large bridges. Quite a number of long span bridges have recently been completed, or are under way, if we include in this class, as heretofore, spans of 1200, 1500 or 1800 feet. But our scale of proportions has been changing. A century ago Telfords Menai Suspension Bridge in Wales, with a span of 580 feet, was pronounced a world wonder. Could it be conceived at that time that within fifty years that bridge would be far outranked by the suspension bridge across the East River at New York, with a span of nearly three times the length and over ten times the suspended mass? And could Roebling have more than visualized that within another fifty years the span of his great Brooklyn Bridge would again be more than doubled and the mass of the suspended weight again increased tenfold in a bridge which is now under construction across the Hudson River at New York between Fort Washington and Fort Lee?

The latter bridge, with its span of 3500 feet, projects into a new range of magnitude and, while it may be years before it will be outranked, there is little doubt that it will be followed by structures of like or greater size, and even a span of twice its length is not beyond present possibilities.

A structure of unprecedented proportions, such as the Hudson River Bridge, is viewed by the laymen with some apprehension as a venturesome undertaking, and when actually accomplished he regards it as a wonder. To the experienced engineer, who has grown up with similar problems of lesser magnitude, it is today but a step farther in the application of well established principles and theories and the utilization of well-known materials and means and methods of construction.

And, in fact, if we analyze the structure of the Hudson River Bridge, as planned, we will find that its integral parts represent but a moderate projection beyond recent precedents, as regards both quality of material and size of structural elements.

It is when we compare the structure with the achievements of the past hundred years that we perceive the great progress that has been made in bridge building, which progress unquestionably has been possible owing to the far reaching advances made in other technical fields, such as metallurgy, electrical and mechanical engineering, as well as in exact science.

But the planning of a great bridge today is more than a structural engineering problem, or the application of scientific and technical knowledge. Not speaking of the political, legal and financial problems, which are necessarily complex and complicated in a public improvement of this kind, the planning of a great bridge as a link in a vast system of transportation arteries is a traffic problem of considerable magnitude.

We take great pleasure in presenting this excellent article to our readers as this structure exemplifies the magnitude of the tasks awaiting the young engineer after graduation. This article will be of special interest to Technology men as the architectural scheme was developed by Cass Gilbert '80.

Nor is the physical planning of a bridge of this size, located in a beautiful landscape and conspicuously exposed to view far and wide, merely an engineering proposition. While the general outlines and proportions are necessarily dictated by engineering requirements, certain parts, as the towers, anchorages and approaches, call for dignified architectural treatment in order to produce a truly monumental structure. And since we engineers of today are not trained in producing the lines and proportions which appeal to the aesthetic sense, it is our duty to seek the association and coöperation in our work of architects who have that training.

Realizing that the Hudson River Bridge presented unusual aesthetic problems, the Port of New York Authority engaged the services of one of the foremost architects, Mr. Cass Gilbert, '80, to assist the engineers in planning the bridge.

Bridge Traffic

The traffic studies which preceded the final planning of the Hudson River Bridge were unusually elaborate and comprehensive. They embraced extensive counts of the entire cross-Hudson traffic from the lower end of Manhattan to Tarrytown. These counts established not only volume, but the location, direction and kind of traffic, as well as its origin and destination and its growth. From these counts estimates were made of the probable volume of traffic which is likely to be diverted to the bridge and these were supplemented by estimates of traffic which will be created by the development of the territory contiguous to the bridge, more particularly of the comparatively undeveloped district on the New Jersey side.

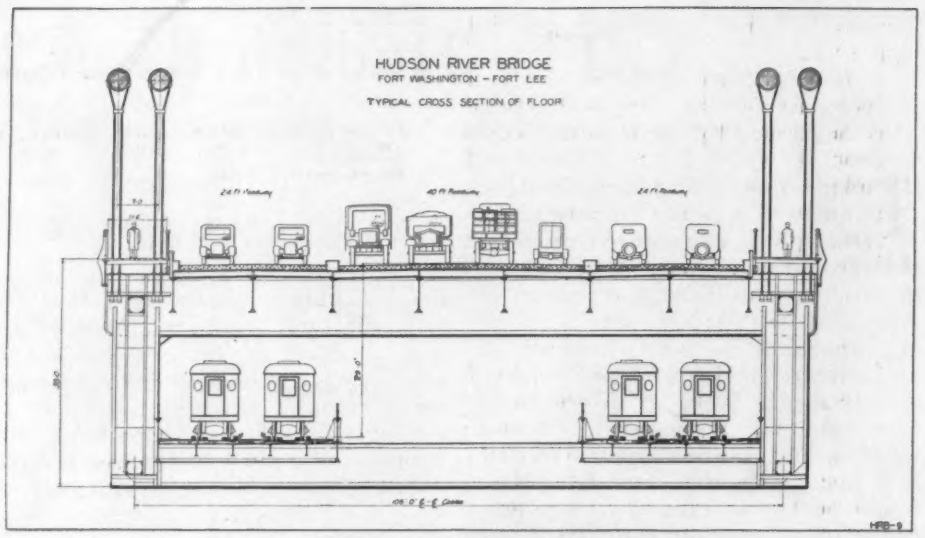
These studies indicate that the fol-

ARCHITECT'S VIEW OF THE NEW YORK PIER
The rocky promontory of Washington Park furnishes a solid foundation

lowing volume of traffic may be expected to cross the bridge when completed in 1932:

Year	Number of Vehicles	Number of Passengers in Vehicles	Number of Pedestrians	Number of Buses
1932	8,148,000	19,898,000	1,415,000	497,000
1933	8,734,000	20,017,000	1,519,000	519,000
1934	9,310,000	21,181,000	1,578,000	544,000
1935	9,870,000	22,387,000	1,690,000	569,000
1936	11,339,000	25,721,000	1,968,000	634,000
1943	13,236,000	31,039,000	2,392,000	812,000
1950	14,997,000	38,567,000	2,890,000	1,092,000
1960	16,310,000	50,362,000	3,196,000	1,616,000

The studies indicated clearly the need for a crossing for vehicular traffic in the vicinity of the bridge and the expected volume of vehicular traffic alone will, with average toll rates of 50 cents per vehicle and $1.00 per long distance passenger bus, produce a revenue sufficient to cover interest and operating charges, as well as sinking fund payments to permit the amortization of the investment within twenty-five years.



CROSS SECTIONAL VIEW OF BRIDGE FLOORS
The lower deck, to be omitted at first, can eventually carry eight tracks in all

The Hudson River Bridge will form an important link between North Jersey and New York State west of the Hudson and New York City. But it will also serve traffic from South Jersey and Eastern Pennsylvania to points in New York State east of the river and New England. This traffic will thus avoid passing through the most congested parts of the city. In conjunction with the existing Washington Bridge across the Harlem River, the proposed Triborough Bridge across the East River to Fort Lee Bridge will establish an uninterrupted highway route between North Jersey and Long Island.

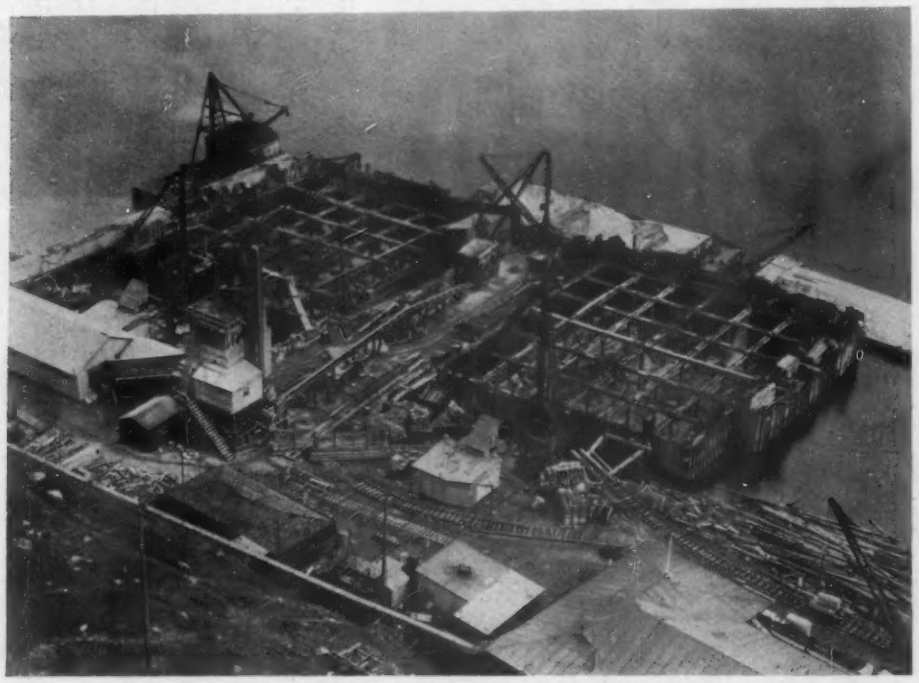
Location, Type and General Proportions

The general location of the bridge is defined by the Legislative Acts of the States of New York and New Jersey as being between 170th and 185th Streets in Manhattan, New York City and points approximately opposite thereto in the Borough of Fort Lee, New Jersey.

This location is well chosen for a bridge crossing, with respect to both the topography and geographical conditions. The ground on both sides of the river in that vicinity rises to a height of 200 feet and more, thus permitting short, comparatively inexpensive, approaches. There is a marked traffic demand in that neighborhood and it is feasible to connect the bridge with important highway arteries on both sides of the river.

Within these limits defined by the statutes, there is one outstanding location which has been chosen for the bridge site, namely on a line parallel to and midway between 178th and 179th Streets, Manhattan. It is conspicuously favorable, inasmuch as it permits a minimum length of river span, the rocky point of the promontory which forms Washington Park offering a solid bed for a bridge pier nearest to the New Jersey shore.

On the New Jersey side, a bridge pier has been located within the pierhead line established by the War Department, since the borings indicated conclusively that it can be built there with foundations reaching to a solid bed of rock not more than one hundred feet below the water level, whereas a pier placed further out would, on account of the rapidly increasing depth to rock and the soft overlying strata, become much more expensive, if not impracticable.



BIRD'S-EYE VIEW OF NEW JERSEY PIER FOUNDATION
This photograph, taken on January 20, indicates the extent to which the work has progressed

Thus the central span of the bridge becomes 3,500 feet between centers of towers and leaves the river between pierhead lines entirely free of obstructions to navigation.

The top of the rocky cliffs of the Palisades forms a natural abutment and offers a solid anchorage for the cables of a suspension bridge on the New Jersey side. For the sake of symmetry, which is essential for good appearance, the side span on the New York side is made the same, or about 650 feet, and the total length of the bridge proper between abutments or anchorages thus becomes approximately 4,800 feet.

The elevation of the bridge floor, as determined by the height of the connecting streets on both sides of the river, is 253 feet above water level. It leaves a clear height of about 200 feet under the bridge, which is ample for navigation.

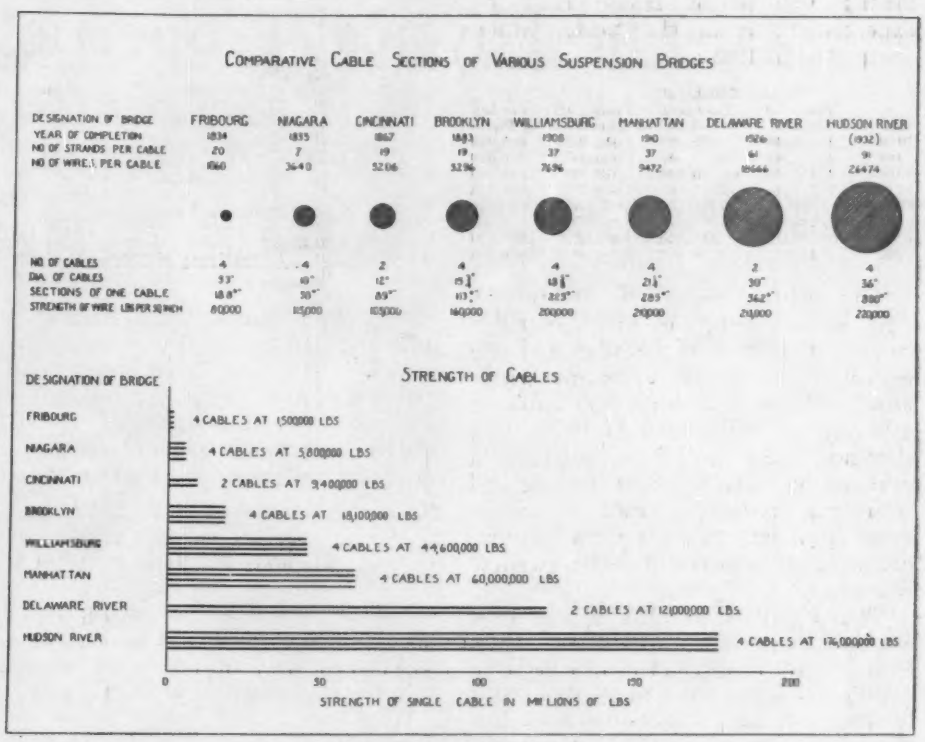
The suspension type of bridge has been selected as being the most suitable, not only on account of its superior economy for such a great span, but also

because of its light and graceful appearance.

A fair conception of the size and proportions of the proposed bridge may be formed by the following comparison with the recently completed Delaware River Bridge at Philadelphia, now the longest existing suspension span, and with the Brooklyn Bridge across the East River, which a generation ago far outranked in size any other similar structure.

General Structural Characteristics

In the conception and development of the design of the proposed bridge the guiding motives, from an engineering point of view, have been purity of type, simplicity of structural arrangement, and ease and expediency of construction, these motives being compatible with true economy, greatest safety and utility and with good appearance. The principal elements of the structure and their functions are simply and clearly defined. The straight, or slightly cambered, floor is suspended vertically from two cables throughout its length. The cables pass over the towers and hang free in their natural graceful catenary, unencumbered by a network of bracing, and are securely anchored at their ends to the solid mass of bedrock on the one side and to a massive block of masonry founded on rock, on the other. The towers which support the cables vertically are plain and massive pillars, and deliver their enormous loads to foundations on solid bedrock.



COMPARISON OF BRIDGE CABLES

The development and increase in size of suspension bridges during the past century is clearly illustrated in the above table

The floor structure is very simple. In each deck simple span floor-beams, sixty feet apart, suspended at their ends from the cables, carry the longitudinal floor-stringers, which in turn support the flooring.

The upper floor is divided into two outside roadways, each 24 feet wide, a central roadway 40 feet wide and two sidewalks. The central roadway will accommodate four lanes of traffic of the heaviest type, having been proportioned to carry safely trucks of 25-ton weight moving at fast speed. Each of the outside roadways will conveniently accommodate two lanes and in an emergency, or intermittently, three passenger cars side by side. They will be proportioned for vehicles not in excess of 15 tons, moving at high speed.

The central roadway and the footwalks are to constitute the initial capacity of the bridge. The traffic studies indicate that it will be sufficient to meet the traffic demand for at least five, possibly ten years, after the opening of the bridge, since they will be capable to accommodate a yearly traffic of from twelve to fifteen million vehicles.

It is intended to erect the outside roadways later which will practically double the initial capacity for vehicular traffic. They will probably be required before 1940.

Although their capacity is over thirty million vehicles annually, it is not expected that the three roadways should normally carry a maximum traffic in excess of about twenty million vehicles, inasmuch as a heavier traffic concentrated at this crossing may cause excessive congestion in the connecting streets. It is assumed that by the time such a volume of traffic is attained, other crossings will be provided. However, a marginal capacity in the bridge is advisable. It is desirable, for the safety and convenience of the traffic, coupled with greater speed, to separate as far as practicable east and westbound traffic, as well as slow service vehicles from fast moving passenger automobiles. It is, therefore, assumed that the outside roadways will eventually serve as speedways for one-way automobile traffic and the central roadway for slow mixed traffic.

Approximately 38 per cent of all

(*Continued on page 28*)

COMPARATIVE BRIDGE DATA

	Hudson River Bridge	*Delaware River Bridge*	*Brooklyn Bridge*
Year of Completion	1932*	1926	1883
Length of River Span	5,500 ft.	1,750 ft.	1,595 ft.
Length of Side Span	650 ft.	752 ft.†	930 ft.
Total Length between Anchorages	4,800 ft.	3,253 ft.	3,455 ft.
Total Length of Bridge and Approaches (between plazas)	7,800 ft.	8,240 ft.	8,016 ft.
Clear Height above Water	200 ft.	135 ft.	135 ft.
Height of Towers above Water	635 ft.	380 ft.	275 ft.
Width of Bridge Floor (over all)	118 ft.	125 ft.	86 ft.
Traffic Capacity			
Sidewalks	2	2	1
Roadway lanes	8	6	4‡
Electric Railway tracks	4	4	2
Total Number Traffic Lanes	14	12	7
Weight of Suspended Structure	90,000 tons	40,000 tons	16,000 tons
Strength of Carrying Cables	350,000 tons	120,000 tons	45,000 tons

*Estimated.
† c. to c. of cable saddles.
‡ Includes two car tracks on roadway.

For both economy and good appearance the stiffening trusses along the floor are made shallow and flexible. They are kept entirely below the upper or roadway floor so as to permit practically unobstructed view from the latter sideways and overhead.

Floor Structure and Its Traffic Capacity

The floor structure is arranged with two decks of which the upper one is to serve vehicular and pedestrian traffic exclusively and the lower one is reserved for rapid transit traffic.

The Physical Properties of Clay

The nature of a material whose properties have puzzled the engineer for centuries

By CHARLES TERZAGHI
Associate Professor of Foundation Engineering, Massachusetts Institute of Technology

THERE is hardly any kind of soil which is apt to cause more exasperating troubles in connection with engineering operations than clay, because in contrast with other materials clay never shows at once what it is going to do. Buildings supported by clay may settle for a long time at an almost uniform rate before they come to rest, and during that period the buildings may go to pieces. Slopes and clay cuts may stand for years without showing any signs of instability, and then all of a sudden they move, whereupon the track or the road becomes buried under a glacier-like stream of pale blue chips and chunks. Near Frankfort, in Germany, a railroad cut was opened some fifteen years ago. Since that time the clay has pushed towards that cut slowly and persistently, and all the efforts to stop its movements have failed thus far. The quantity of excess material which was removed from the cut during the past fifteen years amounts to about 1,000,000 cubic yards.

In order to plan effective remedies for damage caused by the specific character of this material, we must first of all attempt to find out wherein the causes of the detrimental characteristics reside, else one is apt to waste one's money on ineffective methods. In many cases expensive drainage systems have been constructed without producing any noticeable effect on the stability of the drained area, and in other places heavy retaining walls were built where cheap drainage systems would have fully served the purpose. To prevent such failures we must be in a position to predict with a certain degree of accuracy what the effect of our operations is likely to be, and no such forecast can be made unless we are familiar with the fundamental physical facts.

What are these facts? If we disperse a small quantity of clay by shaking it with water and then examine the turbid water under the microscope, there does not seem to be any difference between the clay and a very fine sand. Yet if worked with water into a stiff paste, the clay exhibits the most unusual properties. First of all it is plastic. No matter how fine we grind an ordinary sand it never will acquire plasticity. Another property of the clay is its stickiness, and finally there is the fact that it shrinks if we allow the water to evaporate.

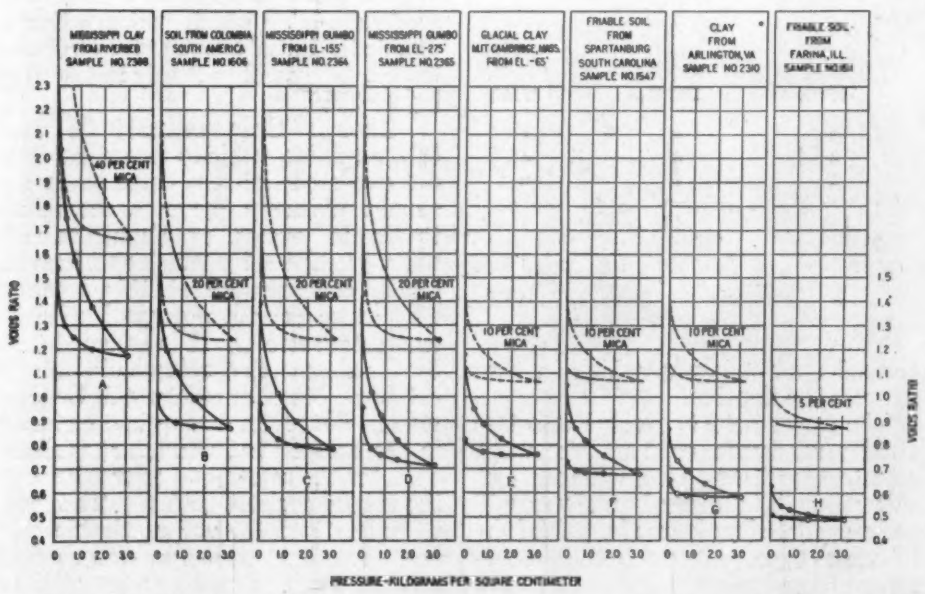

MISSISSIPPI CLAY FROM RIVERBED SAMPLE NO. 2388
SOIL FROM COLOMBIA SOUTH AMERICA SAMPLE NO 1606
MISSISSIPPI GUMBO FROM EL -155' SAMPLE NO 2364
MISSISSIPPI GUMBO FROM EL -275' SAMPLE NO 2365
GLACIAL CLAY MIT CAMBRIDGE, MASS. FROM EL -65'
FRIABLE SOIL FROM SPARTANBURG SOUTH CAROLINA SAMPLE NO 1547
CLAY FROM ARLINGTON, VA SAMPLE NO 2310
FRIABLE SOIL FROM FARINA, ILL. SAMPLE NO 1651
40 PER CENT MICA
20 PER CENT MICA
10 PER CENT MICA
5 PER CENT
A
B
C
D
E
F
G
H
VOIDS RATIO
PRESSURE-KILOGRAMS PER SQUARE CENTIMETER

FIG. 1. Elastic properties of clays and of sand-mica mixtures compared. The full drawn lines show the effect of raising the pressure which acts on confined samples of different clays from 0 to 3kg. per cm^2 (steep compression curve) and subsequently lowering it to zero again (flat rebound curve). The dotted lines show the effect of the same process on those sand-mica mixtures, whose elastic properties bear the closest resemblance to the soils whose diagrams are shown below (Abscissae = pressure in kg. per cm^2, Ordinates = water content). The one difference between the sand-mica mixtures and the clays consists in the fact that the compression and the expansion of the coarse material takes place very rapidly, while the corresponding processes in clays proceed very slowly because of the time required to force the water through the narrow voids.

In the older publications, and even in quite recent ones, the clay character was traced by the authors to the presence in the soil of a colloidal chemical substance called "Kaoline," (aluminum hydroxide). If one inquired why "Kaoline" has such unusual properties no answer could be obtained. It simply was stated as a fact. The first step towards a more rational explanation was made when some investigators expressed the opinion that the plasticity of clay might be due to the presence in the clay of minerals with scale-like particles. Statements of this kind may be found in the papers published by Vogt, (1897), Orton, (1901), Le Chatelier, (1909). However, an experimental proof of these opinions was not presented until 1913. In that year, Atterberg, in Sweden, powdered mica, chlorite, and other micaceous minerals, and demonstrated that the finest fraction of the powders thus obtained were as plastic as heavy clays. The facts were published, but apparently promptly forgotten, because nobody seemed to know what to do with them.

Yet, plasticity is a property which interests the civil engineer less than any other. The engineer needs information about the resistance of the material and this phase of the subject was not taken up until eight years later. In 1921, the writer obtained the first experimental evidence for the tremendous difference which exists between the elastic properties of sand and clay, and he was led to the conclusion that the difference, too, was due to the flexibility of scale-like constituents of the soil. In 1924, in the Soils Laboratory of Robert College in Constantinople, the first data were obtained concerning the relation between the water content, the modulus of elasticity and the compressive strength of plastic clays. From the test results, the laws were deduced on which the relation between the water content and the strength of the clays depend. In 1926, with the intention of checking the hypothesis, that the elastic properties are due to scaly soil constituents, the writer induced Mr. G. Gilboy to investigate the elastic properties of coarse grained mixtures of sand and mica. The tests were performed in the Soils Laboratory of the Massachusetts Institute of Technology, and the results were both encouraging and surprising. They showed that the elastic properties of the clays and of the sand mica mix-

tures are identical to such a degree that one can artificially produce coarse grained aggregates with all the characteristic elastic properties of any clay by properly selecting the percentage of mica. The common clays of the United States approximately correspond to a mixture of about 75 per cent sand and 25 per cent mica. Figure 1 represents some of the com-

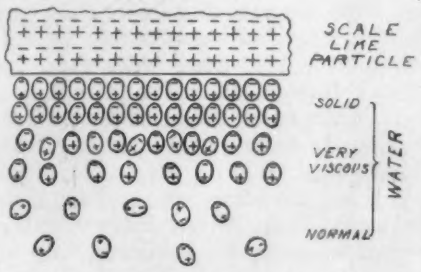


FIG. 3. Layer-lattice of a scale-like mineral particle and the arrangement of the bipolar molecules of the water along the surface of the clay particles.

pression curves of clays obtained by means of the apparatus in Figure 2, and gives a conception of their close resemblance to the compression curves of sand-mica mixtures (dotted curves). Further tests demonstrated that both the elastic properties and the compressive strength of the clays are very different according to the direction in which the external pressure is applied. No such difference could exist in a material with bulky grains similar to those of a sand.

These investigations cleared up the purely mechanical phase of the subject, and the way was prepared for approaching the hydraulic phase. Clay as such is not a treacherous material. It does not become treacherous until it combines with water. Hence, to understand the nature of the interaction between clay and water is still more important than to know the properties of clay itself. One of the first steps towards a deeper insight into this interaction was made by chance. In 1919, the writer failed to dry a couple of small glass plates before he went to luncheon one day, and when he returned an hour later he found that they were sticking to the glass table top on which they rested. The "glue" seemed to consist of gray water spots surrounded by Newtonian color rings. By systematically investigating this surprising phenomenon, he reached the conclusion that water does not evaporate at room temperature if it is enclosed within a space with a width of less than about 0.0001 of a millimeter, (100 micro micron). Within such spaces the water no longer seems to have the properties characteristic of a normal liquid. It acts as a kind of glue, binding the walls of the narrow space together. In 1921, after having carried his investigations still further, the writer was in a position to present experimental facts which strongly indicated that the viscosity of the water contained in very narrow spaces by far exceeds the viscosity of normal water. In the same year, a Michigan investigator, G. J. Boyoucos, who certainly did not know anything about the experiments performed in Constantinople, obtained evidence that part of the water contained in a clay does not freeze even at temperatures of -78°C. Simultaneously, W. D. Harkins, in Chicago, published the statement that the density of the water contained in the voids of charcoal exceeds the density of ordinary water to such an extent that it would require the enormous pressure of 20,000 atmospheres in order to produce an equal increase in density by an external force. Hence Mr. Harkins concluded that the water stayed within the charcoal under a pressure of similar magnitude. At the Fourth National Colloid Symposium, at Cambridge, in 1926, the writer objected to this view on account of the fact that Harkins' hypothesis seems to be physically incompatible with the high viscosity and with the low vapor pressure of the capillary water. He explained the abnormal behavior of the water contained in the clays by the theory that the attraction exerted by the molecules of the solid prevents the molecules of the liquid, in the proximity of the boundary between solid and liquid, from vibrating as freely as they do within a body of normal water. A check imposed upon the vibrations of the molecules of the liquid produces the same physical effect as does the lowering of the temperature. Hence the writer concluded, that the water contained in the very narrow voids of a clay exists in an intensely undercooled state and, as a consequence, has within these spaces the properties not of a liquid, but of a solid.

According to these conceptions, clay represents a mixture of very minute bulky and scale-like particles held together by films of solidified water acting as a glue. The question concerning the origin and the mineralogical character of the scale-like particles remained open. Another puzzle consisted in the low friction values of the clay. In order to make solid bodies as slippery as a wet clay, one must lubricate their surfaces, and experience shows that under ordinary circumstances water never acts as a lubricant. From the engineering point of view it is sufficient to know what the friction value is. Yet one always feels profoundly dissatisfied, if continuously dealing with a phenomenon whose nature is obscure, and the desire persisted in the writer's mind to see the matter explained.

Until some ten years ago even the frictional resistance which acts between a chair and a floor was surrounded with mystery. Almost nothing was known about its true nature until in 1919 W. B. Hardy published the results of his brilliant investigations which showed that the resistance is due not

(*Continued on page 36*)

FIG. 2. Compression-devices by means of which the curves of Fig. 1 were obtained.

Testing Large Waterwheel Generators

A description of new test pit to insure safety in service

By DAVID O. WOODBURY '21
Engineer, General Electric Company

THERE are many problems with which the electrical manufacturer has to deal which do not come under the head of electrical engineering. Some of these come up only occasionally, but one which is ever present is the question of the strength of materials. Whatever the apparatus may be it must be able to withstand the mechanical stresses met with in operation, both to insure a satisfactory long life in service, and to make certain the safety of those handling the equipment. Thus, the transformer must, in addition to its electrical strength, be capable of resisting the mechanical forces produced by load and short-circuit currents, as well as the static forces present in any fabricated structure. Likewise, the circuit-breaker must handle explosive pressures and disruptive forces incident to the sudden interruption of heavy currents, and also provide the rigidity necessary for rapid operation.

The most interesting class of electrical equipment, however, from the point of view of mechanical strength, is undoubtedly rotating machinery, such as motors, generators, and turbines. In them the structure is subjected to every kind of mechanical force, so that it must withstand torque stresses, beam stresses, and centrifugal forces which may readily reach enormous proportions.

The displacement of rotating parts under centrifugal and other stresses cannot be tolerated, since any interference with stationary parts might wreck the machine. In the turbine, for instance, the rotor must be so rigid that the end thrust of the steam cannot cause the blades to strike the diaphrams. Modern turbine design has solved the problem of rigidity by specially heavy rotor shafts and by wheels so proportioned that periodic axial vibrations cannot be set up at normal operating speeds.

In the design of steam-driven generators the clearances are much larger than with turbines and the problem is to hold the parts of the rotor together against the centrifugal forces as well as the magnetic forces impressed upon the conductors. The use of smooth-faced cylindrical rotors makes the mechanical design fairly simple, and a homogeneous construction is obtained with end rings of high tensil strength and with slot wedges.

With waterwheel generators, and with large direct-current generators and synchronous condensers the difficulties imposed by centrifugal forces are much more apparent because of the salient pole construction. Particularly is this true of generators built for use in low-head plants, where the turbine speeds are inherently low. Electrical considerations in these cases require large rotor diameters and heavy pole pieces, both of which factors give rise to very large centrifugal forces. Consequently careful provision against mechanical weakness must be made in the designs. While the loss of a few blades from a steam turbine rotor in operation might cause only minor damage, the loosening of a generator pole-piece weighing a ton or more and traveling at 10,000 feet per minute, would undoubtedly mean general disaster to lives and property. The possibility of such a failure cannot be tolerated, and provision against it constitutes the chief requirement so far as strength of materials is concerned.

TEST PIT WITH COVER RAISED
This lid, four feet thick, is tightly wedged and bolted into place during test runs

All rotating machines of any size are given careful mechanical tests before shipment. For steam-driven units these tests are concerned mainly with balance, which is checked up statically and then dynamically to be sure that there is no vibration present. So successfully is this done with even the largest turbine-generator sets that it is possible to stand a lead pencil on end on the casing and have it remain there until taken away. Dynamic balancing machines are used for these balancing tests, fitted with vibration recorders and other instruments by which it is possible to determine where and how much weight must be added to correct the balance.

The problem of testing low speed rotors of large diameter is somewhat different. Dynamic balance is obtained by the addition of weight where needed. The matter of chief importance in this class of machinery is the guaranteeing of mechanical strength against centrifugal forces, which, as I have stated, are often very large. It is not safe to construct such a machine on theory alone, and by allowing ample factors of safety, to assume that breakage cannot occur. The apparatus must be tested under operating conditions, and, in the case of waterwheel generators, up to maximum or runaway speeds — in other words, double speeds.

Such tests are commonly known as "over - speed" or "double - speed" tests, because the rotor is run at a speed which is twice the value used in normal operation. The reason for this is that the highest efficiency of hydraulic turbines is realized when their blades travel at half the speed of the entering water, their governors being designed to hold them at this value. If an accident occurs, such as the sudden loss of load on the generator, accompanied by jamming of the hydraulic gates or failure of the governor, it is possible for the machine to attain the speed of the water, or twice normal rated r.p.m. It is therefore the custom with this class of equipment to deliver machines only after they have passed this over-speed test for a short period, it being expected that flaws or other weaknesses in rotor construction will show up immediately. Naturally, such tests are dangerous, for if anything does give way the entire mass of revolving metal is liable to break loose

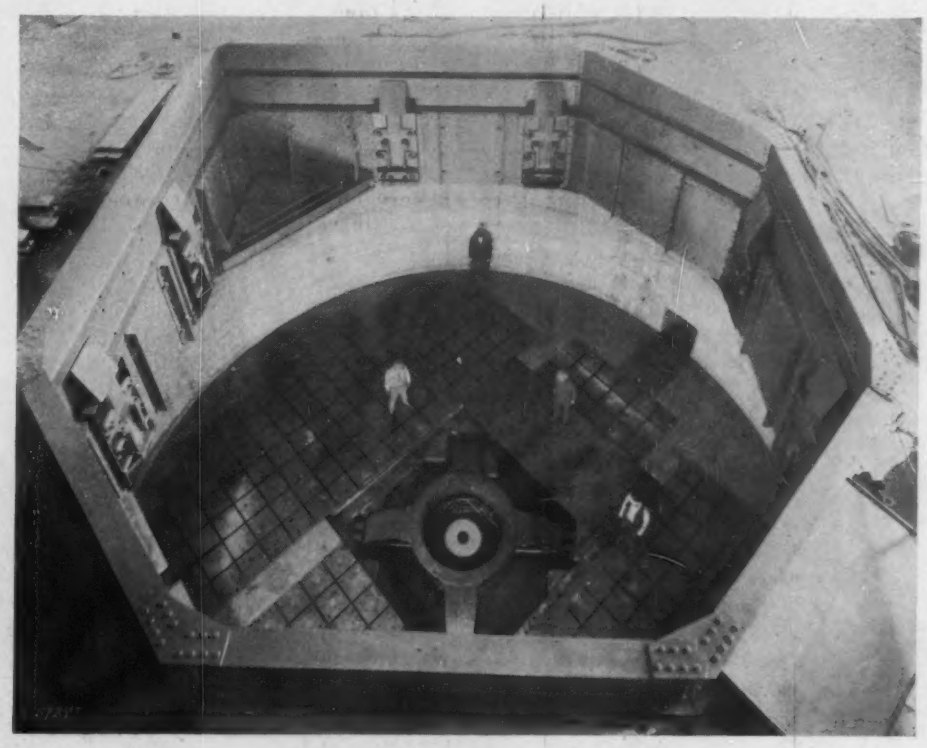
from its bearings and spend its millions of foot-pounds of energy in destruction of life and property.

It has been the custom of the General Electric Company to make over-speed tests of large rotors in heavily lined pits sunk in the floor of the erecting shops. For twenty years such tests have been made without loss of life or serious property damage. But with the constant increase in the size of hydroelectric machines the physical dimensions of these pits have been rapidly outgrown. In 1926 the Testing Department of the Schenectady Works decided to design and build a new testing pit which should be the last word in safety and at the same time be large enough to care for any rotor likely to be built for many years. Accordingly, plans were drawn up and a pit built which occupies a building entirely devoted to testing procedure. At the present writing the new equipment has just been completed, and the first rotating machine is about to go on test.

The test building is a brick and steel structure located in a field a quarter of a mile from the nearest manufacturing building. It is 72 feet wide and 220 feet long, with a crane lift of 50 feet in the pit, which occupies one whole end of the building. The pit itself is a cylindrical concrete shell set down 30 feet below the floor of the building, and resting on a nest of piles which penetrate 60 feet further into the ground. The shell is of double construction. The inner wall has a thickness of 3 feet and is reinforced with one-inch steel bars woven closely together so that a structure far stronger than the heaviest bridge or building construction is obtained. Surrounding this wall a 7-foot cushion of sand is packed in snugly, and outside of that another reinforced concrete wall 4 feet thick. The inside diameter is 45 feet, and the outside, about 75. In the very unlikely event that a flying piece of steel from a whirling rotor should penetrate all of these fortifications its energy would quickly be absorbed by the surrounding earth, without doing any damage. The piers on which the building is set are so arranged that even if a number of them were to be sheared off by flying steel, there would still be enough left to keep the building from caving in. So much for lateral protection.

While the principal forces acting on a rotor under test are in a horizontal plane, there is still some chance of the "pot boiling over." To guard against this, a lid has been provided, which is four feet thick, and constructed of steel plate on a braced I-beam skeleton octagonal in shape. The mouth of the pit is constricted, and around the rim two 30-inch girders are placed, forming an octagonal opening into which the lid fits snugly. Eight brackets are riveted to the girder, and the lid, after being lowered into place, is fastened down with eight wedges each a yard long, which are themselves bolted securely in position.

The minimum diameter of the opening is 30 feet, so that the large rotors — the most modern of which has reached a diameter of 40 feet — cannot be lowered into it until disassembled. One angle of the octagonal opening has been extended so that the pole pieces of the rotor can be lowered into place after the lid has been put on. A small triangular lid fits over this opening and seals up the pit so that stray pieces cannot fly out in case of a smashup.



INTERIOR VIEW OF TEST PIT
The pedestal bearing which supports the rotor can carry a load of 500 tons.

It is not expected that rotors under test will ever "blow up" completely. What is more probable is that relatively small pieces such as fan blades, wedges, bolts, pieces of insulation, etc., might be dislodged by the centrifugal forces, and bounce from the pit walls back against the rotor, thus causing additional damage and perhaps breaking off a larger mass such as a pole piece. This sort of an accident might happen in a fraction of a second, and before the test crew was able to slow the rotor down, the whole mass might break loose.

A recently built whaterwheel generator rotor with a diameter of forty feet carries on its rim 88 pole pieces, each weighing in the neighborhood of two tons. The peripheral speed of this rotor under test conditions would be about 20,000 feet per minute, and a few moments work with a slide rule will indicate that the stored energy would be enormous. In case such an amount of energy were let loose within the pit the damage would, of course, be severe to the concrete structure, but it would be confined wholly within that, and would not include other property or the loss of life. On the other hand, because the accident occurred in the test pit, this relatively small damage would be substituted for the possible wrecking of a large hydroelectric plant and the killing of many people.

All of the large machines to be tested in this pit will be of the vertical shaft type, and in order to support them a pedestal bearing capable of carrying 500 tons is installed in a well below the pit floor. This bearing is of the roller type, and is supplied with oil by a belt driven pump. This lubrication supply, is, however, not relied on during testing, and an electric-driven pump is installed in a chamber in the pit wall to act as a standby. The motor for this pump operates on storage battery current, so that it is independent of the house service circuits.

For the testing of smaller machines a second bearing is provided, which is capable of carrying 200 tons load. This is placed on a bearing bracket resting across the main bearing well, and can be removed when large machines come in for test. There is also room to test the smaller sizes of high-speed horizontal machines within the

(Continued on page 42)

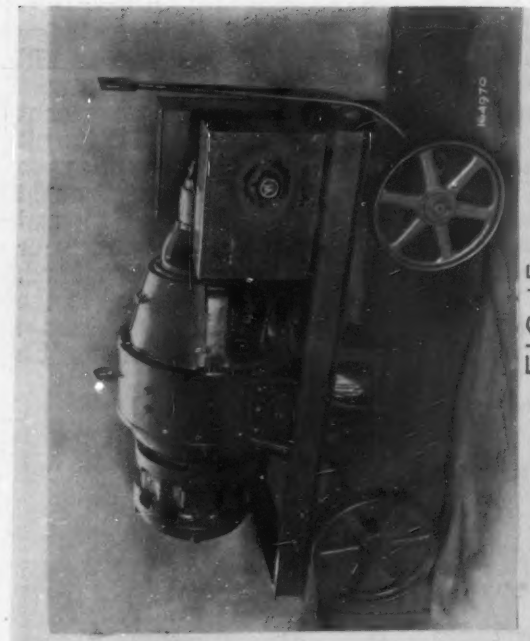


FIG. 15

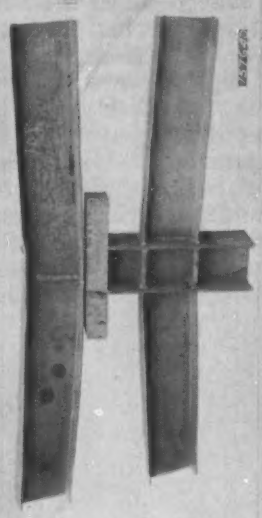


FIG. 8

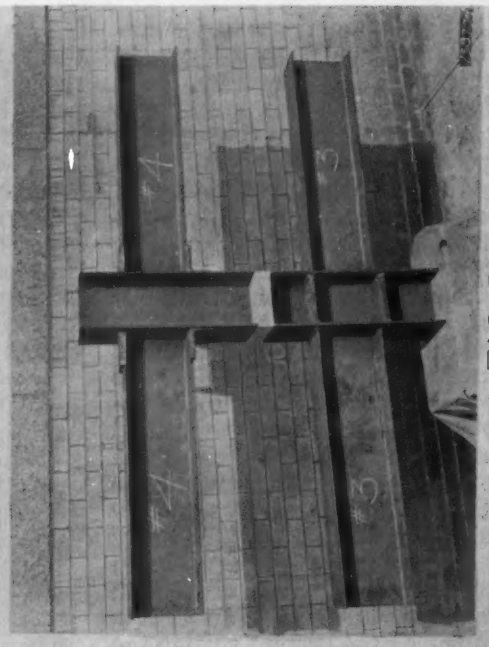


FIG. 6

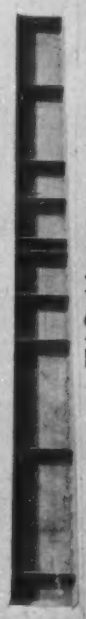


FIG. 11

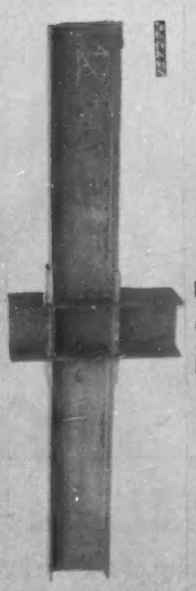


FIG. 5

FIG. 4

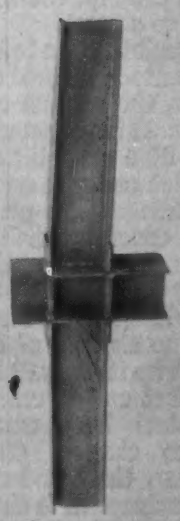


FIG. 7

MADE UPON ARC WELDS

FIG. 14

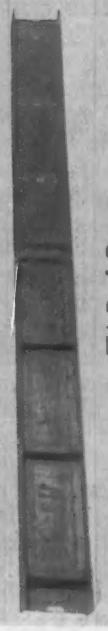


FIG. 10

FIG. 9

FIG. 12

ILLUSTRATING TESTS

Arc Welded Steel Structures

A comparison of the characteristics of welded and riveted joints

By A. M. CANDY
Arc Welding Engineer
Westinghouse Electric and Manufacturing Co.

DURING the last few years, the use of the arc-welding process in manufacturing and building industries has grown rapidly. When this process was introduced, no handbooks or tables of fundamental data were available, but since that time manufacturing companies have conducted extensive tests to develop the data and demonstrate the safety, economy and practicability of arc welding as applied to manufacturing and building. Engineering colleges and trade schools have also helped to promote this new process by adding courses in metallography and arc welding to their curricula, holding arc welding conferences, and coöperating with manufacturing companies in testing arc-welded structures. The information obtained by these tests has been supplemented by knowledge gained by actual application of the arc welding process to many and widely diversified fields.

Arc welding has been used in manufacturing processes for several years. Arc-welded structural steel construction is being used for motor frames, armature spiders, and machine bed plates, all of which were formerly castings. Structural steel products are lighter, stronger, less expensive, and of a more uniform composition than similar products of cast iron or cast steel. The time required to cut and assemble the parts of a structural steel product is much less than the time required to make patterns, molds, and pour metal for castings.

Arc welding has also been used extensively in constructing tanks, gear cases, and other sheet metal products which were formerly riveted. The arc weld produces a good seal, requires no calking, and produces a smoother and neater point than can be produced by riveting. Automatic welding machines may be used in many processes of the sheet metal industry to speed up production and reduce labor costs.

In the oil industry, electric arc welding is becoming recognized as an indispensable agent in constructing pipe lines, making irregular joints, building storage tanks, and in making general repairs on all of the equipment about a refinery. The use of welded seams instead of riveted seams for pressure stills has reduced the number of still leaks and consequently the number of fires and losses due to failures of joints.

These are at present only a few examples of the uses of arc welding in manufacturing processes, but the favorable results obtained are suggestive of many other applications. The remarkable success of arc welding in the manufacturing industry led engineers, architects and others interested in the building profession to believe that arc welding could be used to advantage in the building industry.

The Westinghouse Electric and Manufacturing Company has erected six arc-welded steel frame buildings during the last two years and has recently completed the first all-welded railroad bridge in the world.

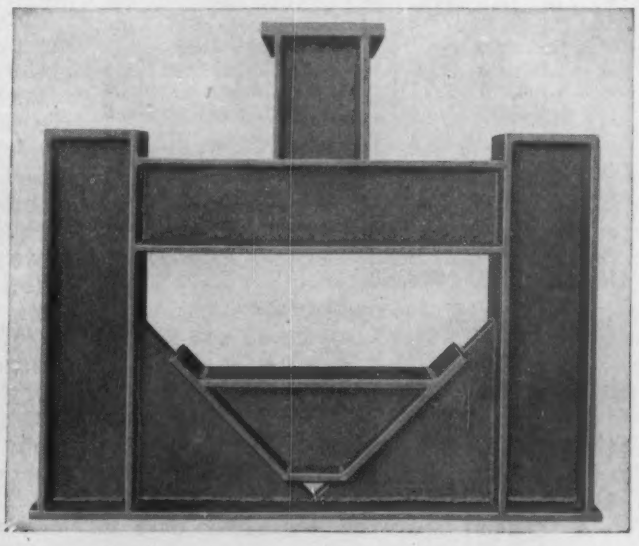


FIG. 13. Showing beam before load has been applied. FIG. 14 shows result

To obtain data for the design of these structures, the Westinghouse Electric and Manufacturing Company conducted a series of tests to determine the strength of arc-welded joints and to compare their characteristics with those of riveted joints. The final tests were held at Carnegie Institute of Technology before an audience of many prominent architects, engineers and builders.

All material for these tests was specially prepared by the American Bridge Company. Insofar as possible all specimens were made of steel prepared from the same heat. This was done to secure uniformity in comparing the various specimens. The riveted specimens were constructed in the fabricating shops of the American Bridge Company and the welded specimens were constructed by the Westinghouse Electric and Manufacturing Company.

There were forty-two specimens made up for testing. In making these specimens, all work which was considered shop fabrication work was done with the specimen in the position in which it was easiest to weld. In other words the welders were allowed to turn them on a table. When making connections that would represent field connections, the specimen was turned until it was in the position which would represent field conditions, so that the work was carried out exactly as it would be on a structure.

Space limitations will not permit a discussion of all of the tests, but some of the most interesting and valuable ones will be discussed in detail.

Three specimens of welded column connections were prepared as shown in figures 5 and 6. Each specimen comprises an H column eight inches deep, two feet high, weighing 32 pounds per foot and two cantilever Bethlehem I beams nine inches deep, three feet long, weighing 29.5 pounds per foot. The details of the specimens are as follows:

Specimen No. 2 (Figure 5) was constructed by welding two seat angles 4″ x 3″ x $\frac{3}{8}$″ x 6$\frac{1}{2}$″ long, across the faces of the column with 4″ legs outstanding. Only the ends of the 3″ legs were welded to the column with a $\frac{5}{16}$″ bead. Four continuity plates each 3″ x $\frac{5}{8}$″ x 6$\frac{5}{8}$″ long were placed against the web of the column between the flanges so as to be directly in line with the flanges of the cantilever beams. These continuity plates were welded in place with a $\frac{3}{8}$″ fillet entirely around their ends against the column flanges. The columns were then stood on end and the I beams were landed on the seat angles leaving a $\frac{3}{16}$″ opening between beam ends and the face of the column. The entire ends of the beams were welded to the column faces and the edges of the beams were welded to the 4″ edges of the outstanding leg of the angle seats. Two top re-enforcing plates each 4″ x $\frac{1}{2}$″ x 4$\frac{1}{2}$″ were placed on top of the beams. The 4-inch lengths were welded to the column face, and the 4$\frac{1}{2}$-inch edges were welded to the top flanges of the beam.

Specimens No. 3 and No. 4 (Figure 6) are similar to No. 2, but the angle seats and re-enforcing plates were omitted in No. 3 and the continuity plates were omitted in No. 4.

Each of these specimens was turned upside, and mounted on rocker blocks five inches wide placed with their centers three inches from the beam ends. The load was applied on the upstanding end of the column.

Figures 7, 8 and 9 show specimens No. 2, No. 3 and No. 4 respectively as they appeared after the tests. The pertinent data is given in the accompanying table.

It is interesting to observe that none of the specimens had a single failure in the welds. Specimens No. 2 and No. 3 failed by web crippling of the I beams and No. 4 by web buckling of the column. The three per cent difference in the ultimate loads required to cause failures in No. 2 and No. 3 indicates the effects of using the re-enforcing plates and seat angles in No. 2. The great difference in the ultimate strength of No. 2 and No. 4 is attributed to the effect of the continuity plates of No. 2. The effect of the continuity plates is the same as that of having a continuous beam carried through the column. This construction was used in the Westinghouse Sharon building.

The three specimens shown in Figure 10, were prepared to determine the strength of arc-welded tension members. Specimen No. 16 comprises a pair of $\frac{15}{16}''$ diameter hot rolled steel rods welded to the two faces of a 12″ I-beam. Specimen No. 17 comprises two angles $2\frac{1}{2}'' \times 2'' \times \frac{3}{16}'' \times 4'$ long with their $2\frac{1}{2}''$ legs placed against two shank plates $\frac{3}{4}'' \times 5'' \times 1'$ long with the angles overlapping the plate ends 4 inches. The heel and toe of each angle were welded along the 4″ length and across the ends of each angle to the shank plates. Specimen No. 18 differed slightly from No. 17 in that the angles were $4'\ 2\frac{1}{2}''$ long, overlapped the shank plates by $6\frac{1}{2}''$, and were riveted to the shank plates with six rivets $\frac{5}{8}''$ diameter, power driven in $\frac{11}{16}''$ diameter holes.

Specimen No. 16 failed by breaking the rod approximately 12″ from one face of the I-beam section. Specimen No. 17 failed through the $2\frac{1}{2}''$ leg first, followed by tearing through the 2″ leg adjacent to the end of the shank plates. The riveted specimen (No. 18) failed through the first rivet hole at the end of the shank plate.

The pertinent data is as follows:

Specimen No.	*Pounds Elastic Limit*	*Pounds Ultimate Load*
16	23,200	35,000
17	70,000	94,000
18	60,000	72,000

In addition to the fact that the welded specimen (No. 17) was more than 30 per cent stronger than the riveted specimen, it is interesting to note that the elongation of the welded specimen was 168 per cent greater than the riveted specimen, the values being 1.12″ over a length of $4'\ 3\frac{1}{2}''$ for the riveted specimen and 3″ for the welded specimen measured over a length of 40″.

To show the advantages gained by substituting arc welding for riveting in built-up members, such as girders and columns which exceed the sizes of existing rolled shapes, four specimen girders were prepared and tested.

Specimens No. 19 (Figure 11) and No. 20 were constructed of similar parts, but one specimen was welded and the other one was riveted. Each specimen comprises a web plate $\frac{5}{16}''$ x 14″ x 15′ four flange angles 3″ x 4″ x $\frac{5}{16}''$; sixteen web stiffener angles $2\frac{1}{2}''$ x 3″ x $\frac{1}{4}''$, and filler plates. A total of 116 rivets $\frac{3}{4}''$ diameter power driven in $\frac{13}{16}''$ diameter holes were used to fabricate specimen No. 20.

Specimen No. 19, Figure 10, was welded. The top flange angles were welded to the web plate by intermittent welds 1 inch long on 3-inch centers along the toe of both the top angles. The backs of the angles were welded together and to the end of the flange plate intermittently using 2-inch long welds on 3-inch centers. At either end the angles were welded solid to the web plate at both the heel and toe for a distance of 3 inches. The bottom flange angles were welded to the web plate solid for a distance of 6 inches at either end of the toe, the remainder of the weld along the toe of the angle being 2 inches on 5 inch centers. The heels of these flanges were welded solid for 6 inches at the ends and the remaining portion of the joint was welded intermittently with 2-inch welds or 5-inch centers. The filler plates were welded to the web plate by means of 2-inch welds at the neutral axis and $\frac{1}{2}$-inch welds at the ends of the filler plates along the web plates. The stiffening angles were completely welded around the entire periphery, making contact with the flange's angles and also 2-inch welds at the heel and toe of these angles exactly in line with the 2-inch welds made at the edge of the filler plates to the web plate.

Specimens No. 19 and No. 20 were designed the same as standard riveted girders are designed.

Specimens No. 21 (Figure 11) and No. 21–A (Figure 12) were designed specially to take all advantage of the possibilities of joining structural steel members by the use of arc welding.

Specimen No. 21 comprises a web plate 14″ x $\frac{5}{16}''$ x 15′ long, two flange plates 10″ x $\frac{3}{8}''$ x 15′ long; and sixteen web stiffener plates 3″ x $\frac{1}{4}''$ x $1'\ 1\frac{3}{4}''$ long. The top flange was welded to the web plate continuously along either side of the web plate. The bottom flange was welded to the web plate solid for a distance of 6 inches from either end and then intermittent welds 2 inches long on 4-inch centers were made throughout the rest of the distance on either side of the web plate. The web stiffeners were welded solid to the flanges around the entire periphery at either end of each web stiffener. Each web stiffener was also welded 2 inches on either side at the neutral axis and at intermediate points 1 inch long at either side of each stiffener half way between the neutral axis and the flanges. This specimen weighed 16 per cent less than No. 19 (the riveted design welded) and 18 per cent less than the riveted specimen No. 20.

Specimen No. 21–A (Figure 12) is the same as No. 21, except that the web stiffening plates are $4\frac{1}{2}'' \times \frac{1}{2}'' \times 1\frac{1}{2}''$ long. Also a reinforcing plate 9″ x $\frac{5}{16}''$ x 6′ long was welded to the top flange. This plate was welded solid across either end and solid along either edge from the center of the girder to a point 1 foot, 2 inches from the center of the girder. The remain-

(*Continued on page 32*)

COMPARATIVE DATA

Specimen No.	*Pounds Elastic Limit*	*Pounds Ultimate Load*	*Bending Moment at Column Face in Inch Pounds*	*Remarks on Ultimate Load*
2	57,000	70,000	1,165,000	No. 2–31% higher than No. 4
3	50,000	68,550	1,130,000	No. 3–28% higher than No. 4
4	28,000	53,400	878,000	No. 2– 2% higher than No. 3

Specimen No.	*Weight*	*Pounds Elastic Limit*	*Ultimate Load*	*Maximum Bending Moment Ft. Lbs.*	*Maximum Fibre Stress Lbs. Per Sq. In.*
19	785	65,000	77,200	270,000	53,800
20-B	798	57,500	71,450	250,000	49,200
21	656	65,000	78,000	273,000	52,700
21-A	795	60,000	110,350	386,000	

Weight

No. 21–A is ½% below No. 20–B
No. 21 is 18% below No. 20–B
No. 19 is 1½% below No. 20–B
No. 21 is 16% below No. 19

Ultimate Load

No. 21–A is 59% above No. 20–B
No. 21 is 9% above No. 20–B
No. 19 is 8% above No. 20–B
No. 21 is 1% above No. 19

Editorials

A SCIENTIFIC EDUCATION

If the students in a technical school were asked to give the reason or reasons which influence them in choosing their particular course, it is safe to say that the answer, "I believe there is more opportunity in this line," would be in the majority. In our opinion, too much emphasis is placed on this method of choosing one's life work. We must pick our specialty at least three years before graduation, and probably four. As regards opportunity in any line, anything might happen in four years. In modern high speed industrial life, industries are created and undermined almost overnight. The knowledge of the specialist today is obsolete tomorrow. However, the fundamental laws of engineering never change. The laws of mechanics are for all practical purposes eternal.

With this in view, the student should choose his work, not to conform to the line which he believes offers the most opportunity at the present time, but to fit his personal abilities and tastes. He should endeavor to receive a thorough grounding in the unchanging fundamentals of the profession rather than specializing in any particular branch. When graduation comes, the entire industry may have undergone radical changes, yet he is still competent to enter any branch, not as a specialist perhaps but with a background that will enable him to swiftly rise to the top.

THE LIBRARY

Within the dome of Building Ten is one of the most complete scientific libraries in this country. There one may find, not only the printed record of achievements in engineering, but also the hypotheses upon which the best brains of the world are building their theories for future successes. While at the Institute, we are necessarily engaged with principles, and only principles, for the most part. Time does not allow us to actually visit the operating plants where much of the knowledge we are gaining is daily put into use. We do not have the opportunity of watching personally the abstract principles at work. The incentive of "seeing the wheels go 'round" is denied us, but — we can use the library, a substitute which may become even more valuable to us than the actual experience. The library is the written record of other men's experiences and can help us to avoid many of the mistakes of beginners, in addition to giving us a rounded-out view of the whole engineering field. We consider that such a view is an essential of every successful engineer.

We cannot hope to be successful in any line of work unless we can see how each particular job is coördinated with every other phase of the process of which it is a part. None of us can fail to do better work in our problem sections, in our home preparation, in our lecture work, if we are continually connecting the problem of the moment with some particular job, with something of which we have read. The best school instruction is estimated to be five years behind the actual methods being used. If we but make use of the library and the facilities that are there offered to us, we shall find ourselves not only more in step when we graduate, but also much better able to meet our problems here with the enthusiasm that a full realization of the opportunities before us will bring.

THE COVER

Our cover this month is a drawing by T. D. Marsh entitled "The Bridge Builders," which depicts the erecting of a girder in a striking manner. This drawing was received through the coöperation of Professor Spofford of the Civil Engineering Department.

STANDARDIZATION

Standardization, one of the most characteristic features of the present industrial system, has come in for a great deal of criticism by various writers on industrial evils. It is claimed that it makes the worker's job a "machine-like, soul-searing monotony." It is robbing work of its savor, and transforming us into puppets incapable of thinking for ourselves.

Yet, standardization is the thing that has made our present standard of life the highest in all history. Newspapers, books, automobiles, and many luxuries, once thought the prerogative of the wealthy, are placed within the reach of the common laborer who enjoys more comforts than any ancient king. Standardization is the very heart and soul of our present prosperity and preëminent position among industrial nations. It is true that it robs industry of some of its savor for the worker, but that is a small price to pay for the benefits which are derived from it.

Furthermore, it is but a temporary price. In our opinion, the cure for the evils of standardization lies in more standardization. When it is pushed to its ultimate conclusion the few evils that have attended it will have disappeared, for the more monotonous a job becomes, the more certainty that it will be replaced by a machine. Therefore, in future years, as this process is pushed to its logical limit, man will be relieved of the need of manual labor. His part will be that of executive or designer, and, largely free of the great burden of earning his living by arduous toil, he will be able to devote his time to the production of a race of "supermen" so long dreamed of by philosophers.

CONCERNING BULL SESSIONS

There is much to be said in favor of that often condemned diversion commonly known to Tech men as the bull session. As one person aptly described it, "the requirements are a number of overworked students, each with several hours of prepared work to do, all night to do it in, and no knowledge whatever of the subject under discussion." This subject under discussion may vary between the widest limits, and, as the session develops, it may follow a devious course from one topic to another, wholly unrelated in character.

Those who are primarily concerned in pointing out the way in which we should go, often deplore the bull session as the ruination of young men. They consider it a needless waste of time, time which might well be used to far greater advantage in application to professional studies.

We feel, however, that the time is not entirely lost. Here at Technology most of our hours are spent in engineering work, and we have little time to devote to those subjects which go to make up a liberal education. In a bull session, we get an exchange of ideas, which, in a small way, serves to bring to us a broadening influence. There is a difference of opinion, and consequently an opportunity to learn to consider both sides of a question and to arrive at a logical conclusion. Men learn to reason things out for themselves and to defend their own ideas against the attacks of others.

With the atmosphere of a bull session there is a certain air of fellowship that seems lacking at other times. Friendships are made, and personalities are seen in an entirely new light. One has a feeling of mental relaxation that is a welcome respite from the daily routine, and for a brief while the bull session takes us into fields where things are not as they really are but as our imaginations would have them be.

The Engineering Field

Abstracts from the leading professional and trade journals

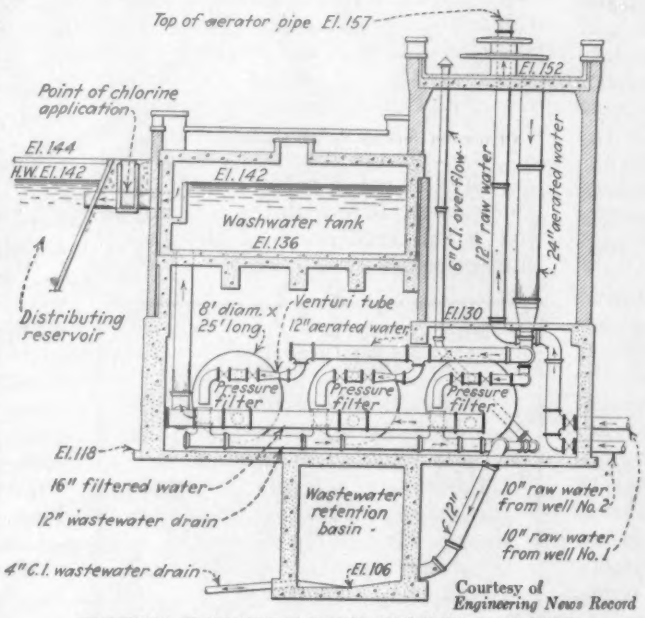
A Small Iron Removal Plant has recently been set up in Red Bank, New Jersey, which is unusual in that pressure filters instead of the usual gravity filters are used. The amount of iron present averaged two and one-half parts per million of water—enough to stain badly.

The total supply was obtained from two wells, one being located in the opposite side of town from the other. Because of the fact that the segregated well pumps were started and stopped at a distance from the reservoir, it was necessary to have the treatment works operate as near automatically as possible without danger of the filters becoming dry or running over in the absence of the attendant. This latter requirement largely determined the use of pressure filters in preference to open gravity ones. As a result, constant attendance is avoided, smaller washwater tanks were used, and the cost was cut tremendously.

The raw water is pumped first to a simple cascade type of aerator from which it flows downward through three pressure filters. Thence, up to a washwater tank from which it spills over a weir into the distributing reservoir.

The three filters are of the standard pressure type, equipped with perforated pipe under drains, 16 inches of graded gravel and 27 inches of sand having an effective size of .43 mm. and a conformity coefficient of 1.48. A difference to be noted, however, is the omission of the wastewater connections on the effluent side — by reason of the fact that all filtered water passes through the washwater tank on its way to the distributing reservoir. The filters are thus back-washed from the tank through the effluent connection and by the filtrate furnished by the two units in service while one is being washed. Because of this arrangement, the Venturi tubes were placed on the raw water pipes instead of on the effluent pipes as is customary.

A New Process for Staining Mortar and Concrete has recently been developed in Germany. It is claimed that the process will improve both the quality of the stained material and also lower the cost. Hitherto, concrete has been stained by employing certain earth colors and metallic oxides called "cement colors." A large quantity of stain was required which made the process costly and also endangered the strength of the material. By the new process the colors are ground with certain inorganic salts either dry or in water solution and then are added to the mortar or cement. The addition of the salts makes the colors more lasting and of a more intense hue, and at the same time reduces the amount of the mineral color to be added.



SECTION THROUGH IRON-REMOVAL PLANT

Electrical Detector of Methane. This device is designed to prevent coal mine explosions caused by the presence of "fire damp" or methane. The detector is a result of research inaugurated by mine operators and legislators of Utah to prevent a recurrence of disastrous mine explosions in that state.

The basis of the detector is a small platinum coil heated to a constant temperature. Slightly heated platinum has the property, when in the presence of a combustible gas, of increasing in temperature. The increase is in direct proportion to the amount of gas present.

The coil is connected to a storage battery by which it is heated, the current from the battery being maintained constant by an automatic control. Any variation in the temperature of the coil is therefore due to the presence of methane in the atmosphere. The temperature of the coil is registered on a dial indicator which is calibrated to indicate the concentration of methane in the air. Surrounding the hot coil are gauze bonnets to prevent an explosion from this source.

The device is portable and can be attached to a telescopic stick of any length, making it possible to explore all parts of a mine without difficulty. The apparatus detects the methane instantaneously, accurately, and with great simplicity.

The new detector will supplant the inadequate devices now being used for the purpose, and its use is expected to put an end to much of the loss of human life in coal mine disasters.

A Flying School for the training of airship crews of the future has recently been designed in anticipation of the day when dirigibles will be the principal means of swift transportation of freight and passengers.

The idea of a training ship is not new, but the present idea is to build a training dirigible which though inexpensive will be large enough to afford training experience identical with that obtained on a full size craft. It will have a maximum speed of 80 m.p.h. and a cruising speed of 65 m.p.h. Internal corridors will make all parts of the ship accessible during flight. The outer cover will be coated with an aluminum preparation making it fireproof and weatherproof. The classrooms, capable of seating fifteen to eighteen students, will be in the rear portion of the dirigible.

The ship has been designed with the idea that there is no substitute for actual experience in the operation of a dirigible. The training will also include a thorough ground instruction in theoretical training, the dirigible providing the necessary finishing touches for the safe and efficient operation of the proposed super-dirigibles of the future.

High Bridge, New York City's Roman type masonry arch bridge, is being reconstructed following the plans of the War Department to provide a channel at least 15 feet deep surrounding Manhattan Island.

The bridge is an outstanding example of Roman architecture in the United States. It was begun in 1839 and completed in 1848 to carry the old Croton aqueduct across the valley of the Harlem River. There are 15 arch spans of granite with a total length of 1,197 feet over abutments. On these arches is an attic story containing the aqueduct which consists of two 36-inch diameter cast-iron pipes and one 90-inch wrought iron pipe, laid about 1864. Only the last will be retained in the reconstruction.

The reconstruction presented many problems such as building a tight cofferdam in a swift river current, maintaining traffic on the river, on the boulevard, and on eight railroad tracks passing beneath the structure. The present plans call for the removal of the attic story, all of the aqueduct pipes and river piers, reinforcement of the abutment piers during these operations, and the erection of the new arch span. The latter will be of a three-hinged plate-girder type, 426 feet long, and will replace five of the present masonry arch piers. The reconstruction will cost $1,190,300.

By replacing five of the granite arches, which are directly over the river, with a steel arch, the greater part of the historic bridge is preserved and its hindrance to navigation removed.

Prevention of Lime Deposits in Water Mains. It frequently happens that lime introduced into water supplies to reduce hardness attains such a concentration as to deposit itself in the water mains. Until lately no practical method had been devised of obviating this difficulty.

A scheme was proposed lately before the American Chemical Society by which carbon dioxide is introduced into the softened water. The carbon dioxide reduces the tendency to deposit calcium carbonate crystals. The gas is introduced by means of an apparatus that is largely automatic. It consists principally of a combustion chamber for the oxidation of the carbon; a washer where the gas is cleaned and cooled to normal temperature; a dryer for removing any moisture that may come mechanically with the gas; and a compressor which raises the pressure to the point where it goes into solution. Diffusers in recarbonation basins uniformly diffuse the gas into the water.

A New Type of Electric Locomotive. Increased production at a central Pennsylvania coal company's mines coupled with conditions existing there, led the company to purchase Baldwin-Westinghouse 22½-ton locomotives developed especially for use under those conditions, instead of the 15-ton locomotives they had been using. Of the two miles and a quarter over which the locomotives operate, a mile and a half is over grades averaging four per cent, running as steep as six per cent, and there are several 150-foot curves. The track has a gauge of three feet. The cars weigh 2700 pounds apiece, and hold 3000 pounds of coal. The average train consists of fifty-three loaded cars. Developing the locomotives in a single unit within the height limitations set by the company was a notable feat.

They are six-wheeled, and have three motors of 90 horsepower apiece. These motors are controlled by a master-controller and nine magnetic unit switches. Of these, two set the motors either in series or in parallel, while the rest operate as accelerating switches. The nine are operated by magnetic action, and are placed at the opposite end from the engineer. This arrangement confines all arcing to the unit switches, and protects the engineer in the event of a short circuit.

The frames of the locomotives are cast steel. The wheels are thirty-six inches in diameter and have steel tires. The front and rear pairs are flanged. The center pair is flangeless and wider than the others. This aids in negotiating the 150-foot curves. The whole, excluding the trolley, is but 49½ inches high.

The performance of the new locomotives is very satisfactory. They make an average of twelve trips per day, with an average of fifty-three loaded cars per trip. The track handles a peak load of sixty cars, and the locomotives handle these easily, not yet having been taxed to their limit.

The "Duck," a new airplane of unusual design is the latest product of a German aircraft firm. The machine reverts apparently to the earlier practice of the Wright Brothers in having the horizontal tail surfaces ahead of the large plane instead of to the rear as is the standard practice today. When in flight, this produces an impression of flying backwards as compared to the usual mode of flying.

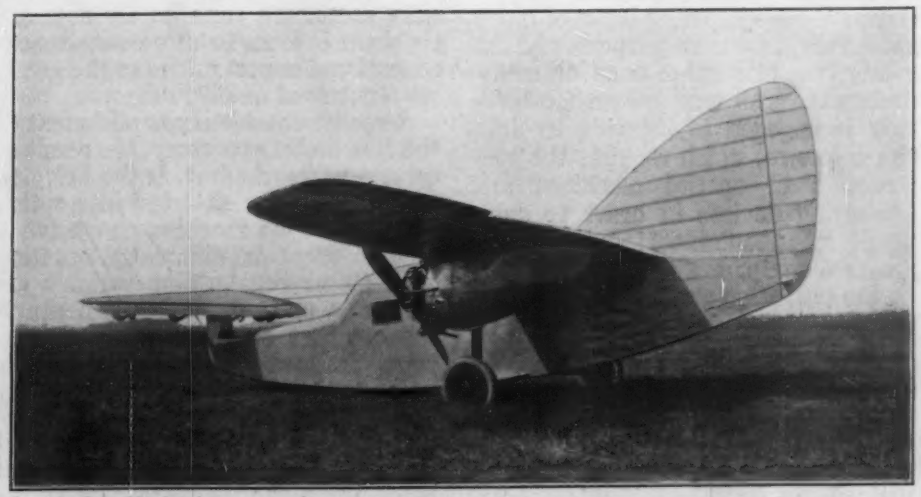
The object of the new arrangement is to lessen the danger of stalling in the air. By this is meant the nosing up of a plane until the lift is lost. When this happens the machine usually gets out of control and there is danger of its going into a spinning nose dive. In an ordinary plane the proper maneuver when approaching a stall is to nose down. The "Duck" is supposed to do this automatically. This is accomplished through the fact that the forward horizontal surfaces being at a greater angle of incidence than the large wing lose their lift first when the plane noses up. Being placed ahead of the center of gravity the forward part of the airplane loses its support. The result is that the machine noses down and normal equilibrium is restored. This theory has been substantiated by tests in flight and exhaustive wind tunnel tests.

Another advantage of the design is the elimination of danger from turning over when landing. The position of the wheels so far behind the forward end of the craft is responsible for this. It is practically impossible for the machine to tip over forward no matter how poor the landing may be.

The reason for having such an extremely large rear fin and rudder is that a plane to be directionally stable must have the larger part of its lateral area behind the center of gravity. When a side gust of wind strikes the machine it will then head into the wind without danger of spinning. Because the "Duck" naturally has considerable lateral area ahead of the center of gravity, this must be compensated by a correspondingly large fin area aft.

Improvement in aerodynamic safety was the object in view when the "Duck" was designed. It may be considered a distinct advance in this respect.

A New Metal Cleaner has been suggested by Messrs. Groggins and Scholl of the color laboratory of the Bureau of Chemistry, Ortho-dichlorobenzene, a by-product of the manufacture of para-dichlorobenzene, mixed with chalk has proved a very effective remover of metal tarnishes. As ortho-dichlorobenzene is almost waste, the new cleaner probably will soon be of commercial importance.



Courtesy *Scientific American*

THE FOCKE-WULF "DUCK"

Reverting to early practice, the tail surfaces are placed ahead of main wing. This arrangement helps prevent stalling

Departmental Notes

ELECTRICAL ENGINEERING DEPARTMENT

THE Graduate Research Laboratory of the Electrical Engineering Department endeavors to provide, in an atmosphere of encouragement and community interest, the physical facilities and guidance of effort necessary for the proper conduct of graduate experimental work. The educational objective of graduate study is to enlarge the depth and thoroughness of knowledge and at the same time cultivate to the fullest extent initiative, scientific inquisitiveness, perseverance, and resourcefulness. The relationship of physical phenomena to mankind is an equally important aim of the graduate educational process. This objective necessarily requires intense specialization in some phase of the art, preferably that phase which is most interesting to the student. As a result the investigational work in this division of the department is highly individual and specialized. The type of graduate investigations carried on is determined by two factors: the first, the most important, is the educational value to the student; the second consideration is the possible use to the art. Even though educational value is given the greater stress in determining the type of graduate research conducted, many of these researches unfold new fields of importance to the art. These new fields usually are followed up and carefully studied by means of departmental investigations which frequently last over a period of years.

To one unacquainted with true research the general appearance of this laboratory is disappointing. The popular conception of research equipment is in terms of expensive, pretentious looking measuring devices and machines; all interconnected with military precision. Such equipment is not of much value except for show purposes and the conducting of routine tests or measurements. The true research laboratory is engaged in bringing to light the unknown, which requires the construction of special machines and measuring devices in order to delve deeply into new fields of inquiry. Actual research equipment hence is generally in the transition stage and, of course, made by the investigator himself. When possible, as a time saver, standard equipment is taken and ingeniously converted to the performance of duties unthought of by its original designer. As can now be guessed the equipment and set-ups present a rather temporary appearance, but rightly so. Such an appearance may be interpreted in terms of worthwhile original work which is in progress.

All members of the Electrical Engineering Department staff may be considered as on the staff of the research division since any investigational problem worthy of graduate effort may be conducted under their direction within the research laboratories. However, for purposes of administration and centralization of authority the division is under the direction of a committee headed by Prof. Vannevar Bush.

In order to carry on the larger departmental investigations there are attached to the research laboratory three, sometimes more, research assistants who are appointed for a period of twelve months only. These men are graduates of excellent colleges who have had at least a year of practice or teaching and who desire to spend a further year in specialized study leading to a higher degree. Besides carrying out departmental investigations each assistant acts as a supervisor to perhaps a dozen or more graduate students in the experimental conduct of their researches. The annual selection of research assistants is from a large list of applicants and is such that as a group it is well balanced. That is, one man may be a practician in bent, another be typically theoretical, still another may have about equal practical and theoretical bents. That such a well balanced working unit should be discarded and another recruited each year with the attendant possibility of retarding the work in process is, at times, criticized; however, this is without due consideration. It is granted that commercial research cannot be economically conducted under the policy of a yearly staff turnover. However, the Institute is engaged in the business of education and purposely risks sacrificing time on its research problems in order to offer most unusual educational opportunities to the greatest number of qualified men.

A recent notable accomplishment of the Research Laboratory, the result of several years of effort, is the bringing to perfection the electrical integrating machine. This machine can solve a second order total differential equation with either constant or variable coefficients, or it can solve two simultaneous first order equations of this type. Such a machine is of inestimable value to the engineer as it can quickly perform mathematical feats which are usually only within the scope of accomplished mathematicians at a great expenditure of time.

Two very interesting pieces of work are now in progress. One is the investigation of dielectric breakdown with the hope of establishing a more adequate theory for this phenomenon. As a part of this investigation there was developed an automatic testing machine into which a roll of dielectric, such as paper, can be fed and there is graphically recorded on a chart the breakdowns and the value of potential at which each breakdown occurs. In this way data for thousands of ruptures could be secured on any one dielectric material within a comparatively short period of time. Incidently the machine also controls the temperature and humidity conditions as desired.

The other particularly interesting work going on is the construction of an improved Cathode Ray Oscillograph. One is acquainted with the usual oscillograph vibrators and the fact that their mass impose a definite limitation to the types of phenomena that can be studied by their aid. Since the Cathode Ray Oscillograph has as its moving element a direct stream of electrons which can be deflected by either electrostatic or magnetic fields we have essentially an oscillograph vibrator of negligible mass. There is also the added advantage that if the electrons have sufficient velocity they will leave their trace on a photographic plate or film. The completion of this apparatus will give a means of studying transient phenomena at present beyond the range of our existing equipment.

Contemplated work in the Research Division includes the building of an alternating current calculating table. Due to the complexity of the transmission networks of present-day interconnected power systems the manual calculations of the effects of short circuits or sudden changes of large blocks of load become impractical and at times impossible. The contemplated calculating table provides a means of duplicating in miniature a power system of generating stations and their interconnecting net work of wires and substations. On this miniature system short circuits or loads may be applied or changed at will and conditions of currents, voltages, and power measured. The equipment on this table is to be adequate for the representation of seven generating stations and one hundred loads or lines, the number and magnitude of the stations and loads to be susceptible to easy variation. Such a table will be able to answer definitely many questions about which we are now in a position to only hazard an answer.

A new integrating machine is planned;

(Continued on page 40)

Knowledge Plus Wisdom

(*Continued from page 6*)

suit, and if he works for an advanced degree, still other years are devoted to progress in the same direction. During all this time no systematic effort has been made to understand human nature and human relationship and his ideas on these important subjects are merely those which he has picked up at random and are likely to be largely erroneous. And yet, when he goes out into the world to do his constructive work, he is nearly sure to find that he is beset at almost every turn with difficult and vexing problems having to do with the human equation and with personalities inevitably associated with him. Then he will learn by costly and often bitter experiences that these human problems must be answered. He will become aware of the existence of envy, jealousy, spite, hatred, malice, selfishness, avarice, arrogance, injustice, falsehood, double-dealing and other hateful and destructive influences. He may even discover, to his surprise, that he is not wholly free himself from some of these human blemishes and failings. In any event, he will have to meet them and defend himself from them as best he may, or run the risk of being overwhelmed by them.

Some of my hearers may think that I am taking a very gloomy view of human nature and that I must think that most of mankind are knaves. On the contrary, I believe that the majority of people are essentially honest and generally try to be just. But one can scarcely live long in the world of affairs and not realize that it is not safe to assume that everybody always means well. It is not good to be oversuspicious, but it is best to be on one's guard. Further than this, it often happens that there is a contention where all of the parties thereto are reasonably honest and intend to be fair. When this comes to pass it is especially important for our young man to well understand both his rights and his duties and it should be remembered that rights always imply corresponding duties.

Now a question presents itself and demands an answer. Is it necessary that young men crammed with learning should go out into the world with no systematic preparation for dealing with these unescapable human problems and be obliged to solve them unaided, out of their, as yet, scanty stock of practical wisdom? Is it not possible and is it not highly desirable that an institution like the M. I. T. should have, for the junior and senior years, a chair called "Humanics" or some other appropriate name, which would undertake to instruct students in the fundamentals of human relationship and move them to think seriously about this subject. It would prepare them to some extent to meet inevitable problems and would in many cases call their attention to their own shortcomings. I think "Humanics" would be the best name for this chair. It is short and very expressive. The word is not given in most dictionaries, but Webster's International mentions it, not in the regular list, but in a footnote, and says it is rare. That is all the better. It is defined as: "Study of human nature." This may seem to you to be a wild scheme. I, however, believe great good could be accomplished through it.

As I see it, the incumbent of the Chair of Humanics, or whatever it might be called, should be a graduate engineer of at least fifteen years of active service in his profession, rendered in various places and positions. It would not be necessary that he be preëminent as an engineer, but he should be of fine personality, with a calm temperament and an abundance of tact. A magnetic and friendly type with sound sense would be very strong, for it would be necessary for him to have a much more intimate acquaintance with the individual members of his classes than is required of others of the teaching force. He should be on terms of personal friendship with as many of his students as possible and be regarded by them as a sort of second father. He should give intense study to his subject and inspire confidence by his ready familiarity with all its details. Such a man would be a great acquisition for any college, but more especially for a school where engineering is taught in all its branches. Such a man might not be easy to find, but there are such men. It would in my opinion be better to have a man who was not a professional engineer if he had the other qualifications, than the reverse.

It may not be easy to see, at first glance, how enough could be said on the subject of human relations to be spread out over courses of weekly lectures covering two school years. If half the hour were given to the lecture and the remainder of the time were devoted to questions and discussions, it would be found that there was plenty to say. If it were attempted to cover such a subject in one lecture, or even in several lectures crowded together, the matters dealt with would not be properly assimilated or remembered. The multiplication table cannot ordinarily be learned in one lesson. The topics must be presented again and again in a variety of ways, if the student is to derive substantial and lasting benefit.

Let us consider for a moment a tentative division of the subject under a number of heads.

1. The proper attitude under varying conditions of a young engineer toward his employer, whether an individual or a corporation.
2. His attitude toward superior officials.
3. His attitude toward those of equal rank in the business.
4. His attitude toward officials of less rank.
5. His attitude toward the rank and file.
6. His attitude toward the lowest grade and least intelligent of workers.
7. His attitude on compensation.
8. His attitude on promotion.
9. His attitude on his effort to render service.
10. His attitude when he believes himself unjustly treated.
11. His attitude when maligned.
12. When it is best to change jobs.
13. The consideration of increasing value as service lengthens, contrasted with new opportunities.
14. Getting along with uncongenial and disagreeable people.
15. Getting along with insincere and dishonest people.
16. What things are worth contending for and what are not.
17. When and how much should one concede or sacrifice.
18. The need of caution when entering into contracts.
19. The need of trying to discover and understand the other man's point of view.
20. The realization that the most satisfactory business is where everybody makes a fair profit.
21. Poor service is dear at any price.
22. The value of optimism.
23. The great value of discretion.
24. The value of eating and sleeping well, whatever happens.

Here are two dozen headings, each one of which would furnish material for a lecture, and the field, I am sure, is not half covered. Can anyone doubt that the young man would profit greatly by thorough discussion and serious consideration of all such topics under competent leadership? If, after two years attendance at such a course of lectures and discussions, he should bring away nothing but the conviction that one of the greatest mistakes a man can be guilty of is to make an important decision while angry, or in any abnormal state of mind, it would justify his having taken the course.

Pope, in his "Essay on Man" says: "The proper study of mankind is man." As a man of letters and a poet, science then being in the cradle, politics a limited field and "big business" unborn, he naturally decided that man was *the* proper study of his kind. Put it *a* proper study and I will agree heartily. We have got to study him some time or suffer the consequences, so we might as well begin when young in order that it may do us the most good. I have had my own experiences in a life of active endeavor and I know

what such instruction would have meant to me at critical times.

Various institutions of learning have their chairs of Philosophy. Courses are given in logic, both deductive and inductive. I, myself, had a taste of philosophy under the late Professor Howison and a mouthful of formal logic also. As a matter of fact I have much doubt that either of these studies has ever helped me much in my efforts to disentangle truth from error. It may be that there are other studies taught in the schools and colleges which tend somewhat toward the understanding of Humanics, but I feel quite sure that nowhere has this subject been taken up in the definite, direct and practical way which I have in mind.

It is not practicable for me to attempt to discuss any of the subjects under the headings just enumerated, but I am disposed to touch briefly on some of the human qualities which help a man on his way in his business career and on some which retard his progress, sometimes to the point of cessation. It can be readily seen that these qualities, both good and bad, have a direct bearing upon the subjects which fall under the different headings.

I think of the fine human qualities as being positive or constructive in their nature. They segregate, build up and strengthen. On the other hand, the mean and bad qualities I think of as being negative or destructive. They disintegrate, tear down and weaken. I am not speaking as a moralist, but from the practical and, if you please, the worldly point of view. You are strengthened by all your good qualities and weakened by all your bad ones. I even believe that an effective test of the merit of any quality is whether it is constructive or destructive. This is of interest to you as applied to yourselves and also as applied to your associates, for their qualities are either helps or hindrances to you according as they are good or bad. Thus it is important that you should be allied as far as possible with people of the right sort.

Let us consider briefly some of the qualities which make for success in the world. Honesty and Loyalty are, of course, most important qualifications. You may be sure that if there is any doubt about these, you will never be invited to participate in the more intimate discussions of the management. These must be above suspicion. It is hardly necessary to discuss the value of honesty. Nobody wants to have a dishonest person as an associate or an employee. The importance of loyalty is scarcely less. It is embarrassing and distressing not to know whether those who work with you or for you are true to the cause, or are traitors. Whether they feel themselves a part of the organization and in full sympathy with it, or are coldly critical and virtually outside it. As long as one is supposed to serve an employer and accepts pay for that service, let him be for that employer in every honorable way. When he cannot do this he should lose no time in getting out of the business. A poor fellow I once knew, who went by the name of Dutch Joe, was charged by a patron with not being loyal. This he denied vigorously and said with an accent which showed his foreign birth: "Whose bread I eats, his song I sings." The employee who says *our* policy, *our* success, indicates that he feels himself a part of the business. If he says *they* do this, *they* want that, when referring to the affairs of his company, watch him; he is not in full sympathy with his job. A certain successful business man once said he would not tolerate an office boy who did not say "we."

Tact seems to me to be a combination of self-restraint and common sense. It does not need to involve deception. Tact goes around an obstacle instead of climbing over it or endeavoring to smash it. Tact takes the path of least resistance and thereby avoids the expenditure of a needless amount of effort or force. Tact is generally conciliatory, but not necessarily so. It will employ the strong arm when that serves the purpose better. To have abundant tact is to be endowed with one of the most valuable possessions. While some people seem to be naturally tactful, none need be without a fair share of it, if they so desire. Children sometimes draw the head of a wheat straw up their sleeves. If the stem end goes first, it moves along without difficulty. That illustrates tact. Then they try to draw it the reverse way and it appears to be full of barbs and little progress is made, but there is much scratching and discomfort. That well illustrates tactlessness.

"If thou faint in the day of adversity thy strength is small." Courage is admirable, but courage tempered with discretion is far more desirable. Josh Billings says that courage without discretion is like a ram with horns on both ends. He will have more fights on hand than he can do justice to. A story I once heard illustrates the idea very well. Two boys were in a pasture where there was an unbroken colt. One dared the other to mount the colt and the other refused. The first called him a coward and said, "Watch me." He made a jump for the colt without taking any precautions and the colt wheeled and kicked him, badly injuring him and rendering him unconscious. Now the boy whom he had called a coward tactfully approached the colt, who allowed him to mount and ride for assistance for the injured comrade. Those who have the reckless, daredevil kind of courage often mistake discretion for cowardice. Courage and discretion work best as complements of each other. "An Indiscreet Man is more hurtful than an Ill-natured one; for as the latter will only attack his enemies, and those he wishes ill to; the other injures indifferently both Friend and Foe."

Patient persistence, coupled with a degree of cheerful optimism, works wonders in this world. The exercise of those qualities not only keeps our own enthusiasm alive, but inspires our associates with confidence and awakens in them an answering enthusiasm. Now enthusiasm is the mother of effort, and without it, so said Emerson, nothing great was ever accomplished. With enough enthusiasm, work becomes play, and hard tasks, if they do not become easy, become at least interesting.

> How poor are they that have not patience!
> What wound did ever heal but by degrees?
> Thou knowest we work by wit, and not by witchcraft;
> And wit depends on dilatory time.

People who sulk when things do not please them are unfortunate, for they are out of harmony with their environment and hence work unwillingly and are unhappy. Said Seneca: "He who willingly submits to another man's command has escaped from the most cruel part of servitude; that is to say, to do that which he is unwilling to do. The most miserable man is not he who has a command put upon him, but the man that does it against his will." Discreet persistence is a winner. It is well illustrated by Polybius as follows: "Some men, like unskilled jockeys, give up their designs when they have almost reached the goal; while others, on the contrary, obtain a victory, by exerting, at the last moment, more vigorous efforts than before." "The more powerful the obstacle, the more glory we have in overcoming it; and the difficulties with which we are met are the maids of honour which set off virtue." "A strong mind always hopes, and has always cause to hope." Cheerfulness is a wonderful asset. In the words of Shakespeare: "Thy smiles become thee well."

The man of generous impulses who deals with those about him with a kindly frankness and who is disposed to help and encourage those who need it, will reap a rich harvest in good will and in moral support when he requires it. In short, follow James Russell Lowell's injunction when he says:

> Be noble! and the nobleness that lies
> In other men, sleeping but never dead,
> Will rise in majesty to meet thine own.

To quote Thucidides: ". . . those are the men to maintain themselves with

credit in the world, who never suffer their equals to insult them, who show proper respect to their superiors and act with thoughtful kindness to their inferiors."

While I was writing this article I fell to musing on all the most successful men I could think of among my acquaintances, and the most vivid impression as to their characteristics that remained in my mind was this: that they were nearly all men of unusually kindly and cheerful dispositions. I thought that this ought to be so, and the result of my count convinced me that it is so. I then concluded that these admirable qualities have something to do with their success.

Let us now turn to some of the negative and destructive qualities which impede the progress and diminish the usefulness of the young man when he has entered into active business relations.

One of the great obstacles to progress and prosperity is anger. People when angry do all sorts of foolish and unreasonable things. They fly in the face of fortune, throw over good positions, estrange their friends, lose valuable opportunities and prepare for themselves no end of trouble. If you have a temper which you cannot always control, learn at least to go off somewhere and wait until you have cooled off and become again rational, before you undertake to transact business or make an important decision. No one can possibly give you better advice than this. If you think that to show anger indicates a high spirit, you are mistaken. It merely shows lack of control and places you temporarily in the ranks of lunatics and fools. You can gain great advantage by keeping your temper under your thumb.

According to Shakespeare, "Conceit in weakest bodies, strongest works." Undoubtedly, Shakespeare was right; he generally was. Conceit rattles around in heads that have room to let. Heads which are well filled with Knowledge and Wisdom have little space left for conceit.

You notice that I have just placed Knowledge before Wisdom, although I have been extolling Wisdom. Well, that is the natural order in life. Knowledge invariably comes before Wisdom. Conceit, egotism and vanity in small doses give zest to life, but it is one of those cases where it does not follow that because a little is good, more is better. On the contrary, modesty is the finest ornament that conspicuous ability and great attainments can wear, and *per contra*, "The greatest of faults is to be conscious of none."

Happy are they that hear their detractions,
And can put them to mending.

"Few persons have sufficient wisdom to prefer Censure which is useful to them, to Praise which deceives them."

Envy, that detestable passion, and its militant twin brother, spite, are wholly destructive and without either profit or excuse. "Envy, the meanest of vices, does not enter the minds of the noble, but creeps on the ground like a hidden serpent." "The surest proof of being endowed with noble qualities, is to be free from envy." "The benevolent have the advantage of the envious, for the envious is tormented not only by all the ill that befalls himself, but by all the good that happens to another." "Jealousy may be in some respects just and reasonable, since its object is only to preserve a good which belongs, or which we think belongs, to us; whereas envy is a madness which cannot bear the good of others." The foregoing quotations from eminent writers make it plain what envy really is, the meanest of the passions. Unfortunately, envy is not a rare thing, but luckily the possessor of it is the greatest and very often the only sufferer from it. People often say, "I envy you this or that." It is only a loose way of saying that you are possessed of something which they like or admire and that they desire to be similarly provided. They are not confessing that they are really envious. No wise person will allow envy or hateful spite to have an abiding place in his mind. They are very uncomfortable companions and they waste the energy and retard the progress of those who harbor them.

Lord Bacon very well said ". . . he that studieth revenge, keepeth his own wounds green." And my old friend Josh Billings declared "Thare iz no pashun ov the human harte that promises so mutch and pays so little as revenge." Of course it is quite possible that we, or more particularly those whom we hold dear, may suffer a deliberate injury so great that our sense of justice and honor demands that the offender shall pay a sufficient penalty therefor. But such cases are comparatively rare. Most revengeful feelings are excited by lesser wrongs or fancied wrongs. Little things are constantly happening which offend us. Now if we make grievances of all these little provocations and study to "get square" with their authors we shall, like Josh Billings' goat with two sets of horns, have more fights on hand than we can well attend to. Further, we shall use up much time and energy to no good purpose. It is a great mistake to be too quick with reprisals. They do not pay, whatever they may promise. Envy, hatred, spitefulness, jealousy, revengefulness, malice, these are malignant attributes and they will exact a penalty from their possessors. Avoid them and resist their advances. I wish to reiterate, I am not preaching morality. I am trying to expound that worldly wisdom which is so closely coupled with your success in practical life.

Another group of undesirable qualities may be summed up under the head of hypocrisy and pretentiousness. "Hypocrisy is the homage vice pays to virtue." "If the devil ever laughs it must be at hypocrites; they are the greatest dupes he has; they serve him better than any other, and receive no wages." "He who backbites an absent friend, who does not defend him when he is attacked, who cannot keep a friend's secret; that man is a scoundrel! Mark him, and avoid him." "He who wishes to do mischief is never without a reason." "Traitors are hateful even to those who gain by their treason." The hypocrite pretends to be what in truth he is not, and usually for some evil purpose. He is double-faced and false. When you detect signs of this quality, be doubly on your guard. Pretentiousness is not quite as bad as hypocrisy and so easily drops into the ridiculous that the possessor is usually the only one damaged. I am reminded of an impudent but witty rascal who, seeing a very pompous looking man across the way, ran over to him and touching him on the arm said: "I beg your pardon, sir, but are you anybody in particular." "We are never made so ridiculous by the qualities we have as by those which we pretend to have."

Egotism and vanity are comparatively harmless failings, unless carried to great extremes. Josh Billings says: "There is no kure for vanity; gittin thoroly wet comes the nearest to it, for the time being." Both egotism and vanity may be so displayed as to be very irritating and even obnoxious to the beholder, but they are more likely to partake of the humorous or sometimes of the comic. George Eliot likened a certain vain man to a cock, who thought the sun had risen to hear him crow. "He who gives himself airs of importance exhibits the credentials of impotence." There is, however, one important aspect of egotism and vanity. It is this: if the world believes that you are possessed of more than an ordinary share of these weaknesses, you may find it difficult to make the world take you seriously when you especially desire to be so taken.

"The gain which is made at the expense of reputation should be set down as a loss," so said Publius Syrus. Cassio felt the full force of the disaster when he exclaimed, "O, I have lost my reputation! I have lost the immortal part of myself." "Oaths are not the cause why a man is believed, but the character of the man is the cause why

(*Continued on page 26*)

Recent Books

This department conducted in co-operation with the faculty

PROPAGATION OF ELECTRIC CURRENTS IN TELEPHONE AND TELEGRAPH CONDUCTORS. *By* J. A. FLEMING, M.A., S.Sc., F.R.S. *D. Van Nostrand Company, Inc., New York. Price $8.00.*

In the fourth edition of this book, well known to students in power transmission and communication fields, the text is identical with that of previous editions except for the addition of a new chapter covering recent advances in the construction and use of lines and cables. As the title indicates, the author is mainly concerned with the theory of propagation of electromagnetic waves on parallel wires and in cables. While some consideration is given at various places throughout the book to measurements, plant and practice, the theoretical aspects of the problem are distinctly emphasized.

In the mathematical introduction the author reviews the mathematics of complex quantities and of hyperbolic trigonometry in an illuminating manner, with various graphical interpretations, summarized by tables of useful formulæ.

Following the derivation of the equations of wave motion from the differential equations of the system, a mechanical analogy is given to illustrate the electric and magnetic forces which are set up. This analogy is likely to prove confusing if read too literally. Starting with the assumption of an applied rectangular wave of e.m.f., the formation of waves and their propagation along a line is considered very briefly. Transition is then made to the application of sustained sine e.m.fs, under steady state conditions only. In treating of the propagation of the wave front, account is taken of reflections at the distant end of the line, on the basis of a "stretching" of the lines of electric strain in the case of an open line, and on the basis of the disappearance of these lines in the case of a short-circuited line. The steady state solutions cover the various cases — "infinite" lines, finite lines with open and short-circuits at the far ends, as well as finite lines with loads of various impedances.

Under "Principles of Telephony" a discussion is given of Fourier's theorem as applied in the arbitrary analysis of complex wave forms, in cases where the coefficients of the system are constant. No mention is made of the inapplicability of this conception in treating systems involving non-linear coefficients. The development of "distortionless" and "loaded" circuit theory follows the work of Pupin and Campbell. An interesting mechanical device for showing waves on loaded strings is described, which serves in a beautiful manner to visualize the performance of electrical lines.

In the study of propagation of waves in submarine cables, consideration is given to the calculation of arrival curves for simple transmitted signals, as a means of illustrating the distortion and lack of definition obtained in the signals as received over long cables. Some space is devoted to means for increasing the speed of transmission over cables, as dependent upon the system of operation used, multiplex circuits and the alteration of the cable constants by permalloy wrappings.

The author touches upon the propagation of very high frequency waves on wires, where the dimensions of the system become large compared with the wave length. More complete expositions on this subject may be obtained from literature dealing with radio frequencies. Dealing with extremes, the author also considers the propagation of very low frequencies. These considerations are of use when as many channels of communication as possible are to be maintained on a given pair of wires.

Standard methods of measurement of line and cable constants, as well as the measurement of inductance, resistance and capacitance, are described, but in considering apparatus, the book deals entirely with British equipment, which makes this section less useful to the engineers of this continent.

In the new chapter covering recent advances in the art, the examples given are disappointingly behind the times, due undoubtedly to the time required to prepare and print the book. Special constructions in multi-wire cables are described in some detail; other subjects covered include iron-dust cores in loading coils, phantom circuits, lump-loaded and uniformly-loaded telephone cables without "permalloy," and cables utilizing "permalloy." Thermionic repeaters, carrier systems and filters are given a very brief description.

To the student in electrical engineering, interested in the transmission of small or large amounts of power over lines and cables, this book will serve as a valuable reference.

JAMES K. CLAPP.

STEEL AND ITS HEAT TREATMENT. *By* D. K. BULLENS. *John Wiley & Sons, Inc., New York, 1927. Chapman and Hall, Ltd., London. 564 pages, illustrations, diagrams, tables. Price $4.00.*

This book was originally written to give the layman a general knowledge of the heat treatment of steel, and of the properties of heat-treated steel.

The third edition, just published, brings the work up-to-date, and in addition contains much hitherto unpublished material. The first section of the book deals with the metallurgical phase. There are many excellent photomicrographs in this section as well as charts and tables.

The second section deals with the engineering phase and discusses various alloy steels. The most recent work on "Molybdenum Steels," "Tungsten Steels," "Uranium, Zirconium and Cerium Steels," and "Chronium Steels" is discussed at length. High speed steels are also very thoroughly dealt with, and are illustrated with photomicrographs.

The production phase is taken up in the third section. This treats of the principles and practice of industrial heating as applied to heat-treating processes. A very interesting chapter in this section explains the difference between "control of temperature" and "control of the heat-treated product." This point, which is not generally understood, is explained fully, and the way to avoid making errors in temperature control in industry, which are so disastrous to product and profit, are clearly set forth. Chapters on "Selection of Heat-Treating Equipment" and "Electrical Equipment for Heat Treating" give the very latest information on these subjects.

The book is written in such a way that a man not very well versed in the art of heat treatment could understand it and derive a great deal of benefit from it.

J. S. M.

INTRODUCTION TO CONTEMPORARY PHYSICS. *By* KARL K. DARROW, *Member of the Technical Staff, Bell Telephone Laboratories. D. Van Nostrand, Inc., New York City. Price $6.00. 449 pages, illustrated.*

This book should appeal to all students at the Institute as a summary of the present status of atomic and subatomic physics. Dr. Darrow published a series of articles in *The Bell System Technical Journal* which contained a great deal of the material now available in this volume. This book, however, is not a collection of reprints, but has been completely rewritten so as to bring the work entirely up-to-date and to avoid repetition. A great deal of the material was presented to students at the Institute by Dr. Darrow in a lecture course which he conducted some time ago, which makes this book of exceptional interest to Technology men.

The author discusses the different atom models which have been used to explain various phenomena and reconciles some of their apparent inconsistencies. The atom model is regarded as a creation of the scientific inauguration to explain some definite phenomena in contrast with the experimental atom which has three definite physical qualities. These qualities which may be called the features of the experimental atom are mass, magnetic moment, and detachable change. All atom models must include these qualities as a framework, but then they can add other qualities to explain particular characteristics.

The first chapter is devoted to a discussion of the experimental electros. Precisely as with atoms, the electron of experiment is one thing and electron of theory is another. There is an experimental electron with a few simple and perfectly definite characteristics which have been experimentally determined, and there are many electron models which pass additional qualities so that the models may be used to copy certain phenomena, such, for instance, as those of radiation.

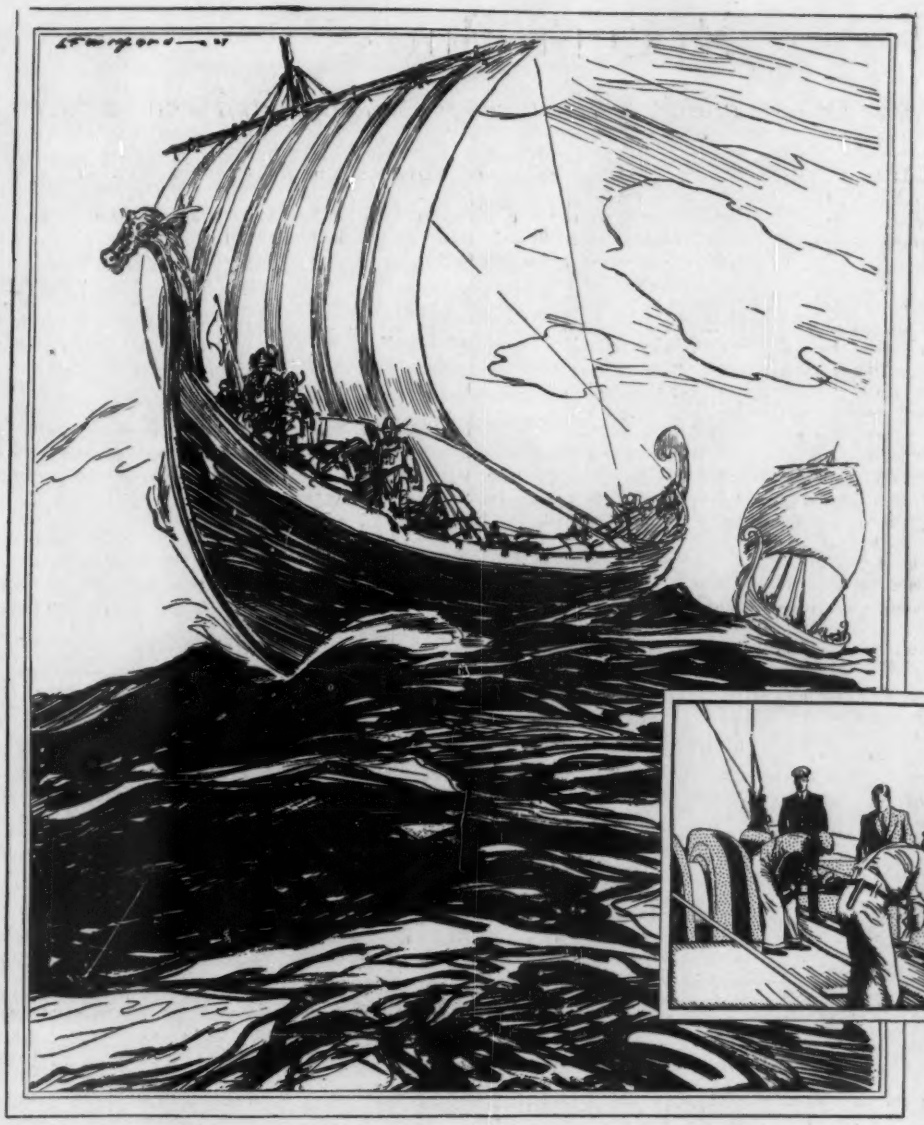
The properties of the experimental atom are described in the second chapter and the third chapter divides the properties of the elements into three classes, those which increase or decrease equally and steadily, those which vary periodically, and those which vary irregularly along the periodic table. From the data described in the second chapter the nuclear atmodel is constructed to explain the variations of the different classes given above. The periodic properties are ascribed to outer electrons, the non-periodic properties to inner electrons, and the irregular properties to the nucleus.

The fourth and fifth chapters take up the deflection of alpha particles and electrons by matter. The nuclear atom-model was originally devised to explain the scattering of alpha particles by matter, and it is admirably adapted to this purpose. The sixth chapter is devoted to a consideration of the quanta and wave theory of radiation, as much of the material presented in the seventh and remaining chapters is dependent on our understanding of radiation. The seventh chapter takes up the detachment of electrons from atoms and molecules under simple and relatively intelligible conditions.

Chapter eight is the first of five chapters on the stationary states. The author points out that "the stationary states are facts of experience and not merely theoretical consequences of a particular model for the hydrogen atom. They constitute the great fact of experience, recognition of which makes the difference between the physics of the years before 1913 and the physics of the years thereafter."

The thirteenth chapter considers the conduction of electricity through gases. As a great many of the facts concerning the experimental electron, the experimental atom and the detachment of electrons from atoms were discovered as a result of research on the electric discharge in gases, some mention must be made of this phenomena.

The book is very well written, and the illustrations are very good. This treatise is doubtless one of the outstanding contributions to the literature of contemporary physics during the past year.



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Knowledge Plus Wisdom

(*Continued from page 23*)

the oath is believed." While speaking of the inestimable value of a good reputation I cannot omit to mention Josh Billings' version. "Tew enjoy a good reputashun give publickly, and steal privately." This advice, as far as it goes, although somewhat satirical, is very practical.

If a man finds that he has a tendency to be somewhat insolent to his superiors and arrogant with his equals and subordinates he had best check this tendency and accept the following admonition from Shakespeare: "Mend thy speech a little, lest it may mar thy fortunes." Nothing good can come of over-brusque manners.

"Do you wish to instruct? Be brief, that the mind may catch thy precepts and more easily retain them." Verbosity fatigues and confuses the listener. In Shakespearean phrase:

> He draweth out the thread of his verbosity
> Finer than the staple of his argument.

"The extreme pleasure we take in talking of ourselves should make us fear that we give very little to those who listen to us." Josh Billings said: "I prefer the gravity of the owl to the loquacity of the magpie. It is better to look wise than to talk foolish." "He who sedulously attends, pointedly asks, calmly speaks, coolly answers, and ceases when he has no more to say, is in possession of some of the best requisites of man." "An able man shows his spirit by gentle words and resolute actions."

> Big words do not smite like war clubs,
> Boastful breath is not a bow-string,
> Taunts are not so sharp as arrows,
> Deeds are better things than words are,
> Actions mightier than boasting.

We certainly have the right to defend our opinions. Indeed, it sometimes happens that it is important or even imperative that we do defend them, but, it seems to me, it is possible to be too controversial and too prone to take up the cudgels when the victory, if we win it, will be a barren one. Heated argument leaves more or less irritation behind it and we had best be sure that the game is worth the ammunition. We do not need to furnish proof for every belief we hold and the average man, . . . "convinced against his will, is of the same opinion still." It is quite certain that some people injure their prospects by being unnecessarily argumentative. It is also well to remember that "it is much easier to be critical than to be correct."

The French proverb says: *Tout vient qui sais attendre.* Usually translated, "All comes to him who waits." Anybody ought to know better than that. *Sais* is from *savoir*, to know. If the proverb means anything, it means that things come to those who know how to wait, the inference being that they are, if possible, helping things along while they wait. Don't merely wait for a job, hunt it up. Josh Billings says, "A man who kant find ennything to do, generally hunts with grate caution."

In discussing business matters with others, especially with strangers, it is better to discreetly let them do most of the talking. When you are talking, they are learning about you and your affairs, if you are dealing honestly with them. When they are talking, you are learning about them and it is a pretty shrewd man who can talk very long without disclosing to you a great deal that he does not intend you to know, provided you listen attentively. "Nature has given us two ears but only one mouth." When you play a game of cards, you do not tell what cards you hold, but try to figure out the hand of your opponent. Nor does he show you his hand, but he endeavors to ascertain yours. That is business, whether you like it or not, and it is quite legitimate, if the players do not cheat. Sad to say, some players do cheat and have to be watched very closely.

Learn to use your analytical faculty when considering business matters and go to the bottom of your problems.

> Errors, like straws, upon the surface flow;
> He who would search for pearls must dive below.

This is illustrated by the following: "Everyone who enjoys thinks that the principal thing to the tree is the fruit, but in point of fact the principal thing to it is the seed. Herein lies the difference between them that create and them that enjoy."

People are thought sometimes to be lucky and sometimes to be unlucky, but the Goddess of Fortune, although coy, can be placated to a very considerable extent. In the words of Burns,

> To catch Dame Fortune's golden smile,
> Assiduous wait upon her.

"Fate leads the willing and drags the unwilling." "Fortune is not on the side of the faint-hearted," and "There are few chances so unlucky from which clever people are not able to reap some advantage, and none so lucky that the foolish are not able to turn them to their own disadvantage." "Fortune never appears so blind as she does to those on whom she confers no favors."

It is generally conceded that a goodly share of enthusiasm is a desirable thing to have. It is not so generally realized that it is of great importance to us how our enthusiasm is expressed to others; especially to our superior officers or to shrewd business men whom we wish to impress with our own fitness, or with the merits of the proposals which we present to them. You will note that men of large affairs and much experience seldom allow their own enthusiasm to approach the point of ebulition. They talk about matters, over which they are much enthused at heart, with calmness and a certain cautious reserve, which plainly shows that they are not unmindful of instances in the past, when very promising things have turned out to be disappointments. Now when any of you young men have either your service or your plans to present to the worldly wise, remember that the enthusiasm which visibly bubbles and overflows through the mouth, and all unreasonable cocksureness, are more than likely to cause your listener to believe one of two things; that you are an honest visionary who makes up his mind without sufficient reason, or that you are talking in strong terms with the intention of deceiving. Enthusiasm is shown to the best advantage in the quality and quantity of the work you do.

Being of a somewhat enthusiastic temperament, I have often felt, after an interview with an able business man, that I had not used good judgment in the presentation of my case. In fact, that I might have prejudiced my case by appearing oversanguine. Thoughtful men of affairs are much more impressed by moderate statements backed up by sound reasoning and cold facts than they are by forcible statements with weak support when they ask for the proofs.

One's choice of friends is a very important matter. They should be chosen from among our superiors in position and attainments when possible, or from our equals at least. Then we may profit by their Knowledge and strength. "Make not a Bosom Friend of a melancholy soul; he'll be sure to aggravate thy adversity, and lessen thy prosperity. He goes always heavy loaded; and thou must bear half." "Consider again and again the character of the man whom thou recommendest, lest the faults of another should, by and by, bring a blush to thy cheeks." "Take care that no one hate you justly." Josh Billings says: "When you cum akrost a man that neither flattery nor abuse wont stimulate, let him alone, he has gone to seed." "It is with narrow-souled people as with narrow-necked Bottles; the less they have in them, the more noise they make in pouring it out."

Go about things calmly and thought-

(*Continued on page 30*)

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The Hudson River Bridge

(*Continued from page 9*)

material in the floor system will be structural carbon steel with a minimum strength of 58,000 lbs. per square inch. Fifty-six per cent will be silicon steel with a minimum strength of 80,000 lbs. and 6 per cent will be nickel steel with a minimum strength of 90,000 lbs. The respective basic permissible unit stresses in tension are 20,000, 27,000 and 33,000 lbs. per square inch.

The lower deck is to be omitted at first and erected after the opening of the bridge for initial capacity. The passenger traffic studies indicate that demand for it may arise within ten years after the opening of the bridge for vehicular traffic, and possibly earlier. At that time the lower floor may be proportioned to carry up to eight rapid transit tracks, since the suspenders, cables and towers will have ample strength to carry this additional load.

Vertical and Horizontal Stiffening Systems

For the sake of structural simplicity and to avoid ambiguous distribution of load, the cables and suspenders have been arranged in two vertical planes and the floor frames are therefore suspended at two points only, one on each side of the floor. In the planes of the suspenders, the cables hang almost perfectly free except insofar as they are restrained in their vertical and horizontal deformations under load by the relatively flexible floor. The great weight of the cables themselves and that of the floor suspended from them lend them ample stability and rigidity and do not necessitate as rigid a stiffening as that of smaller and lighter suspension bridges. In fact, the relatively shallow stiffening trusses placed along the floor between the upper and lower deck are an outstanding characteristic of the proposed design. While supplying ample local rigidity, they are sufficiently flexible to follow the deformations of the cable as a catenary. Being relatively inconspicuous, these trusses enhance the simple, light and graceful appearance of the structure. At the same time they effect far-reaching economy when compared with the rigid system of smaller bridges. In a bridge of this size, in which every pound of steel wasted in the floor means another pound wasted in the suspenders, cables, towers and anchorages, which have to carry it, such economy runs into millions of dollars.

The horizontal or wind stiffening system in the plane of the upper floor, whose chords form the upper chords of the vertical trusses, while amply rigid to resist the heaviest wind pressure, is likewise comparatively flexible, with the result that in deflecting it produces effective counteraction by the heavy suspended cables, and is thus relieved of a large part of its wind load with a resulting marked saving in metal and cost.

Thus the characteristic of the suspension type of long span, the stability and inherent rigidity of its heavy suspended cables, is made use of to the fullest possible extent.

The members of the stiffening trusses will be partly of Carbon steel and partly of Silicon steel. The permissible stresses are the same as in the floor system.

The Cables

The cables naturally form catenaries. In the center span the latter forms a relatively flat and graceful curve, the sag at the center being only 325 feet, or about one eleventh of the span length. In the side spans owing to the short length of the latter, the catenary is only slightly curved and falls at a steep angle towards the anchorages. As already explained this arrangement is dictated by economy, as well as by the topographical conditions.

From the inception of the project it was realized that there were available for the cables two types which could compete economically, namely the cable composed of parallel high tension drawn steel wires, and the cable composed of high tension heat treated forged eyebars.

Both of these types have reached a high degree of perfection in American Bridge construction and both make excellent and safe tension members for suspension bridge cables.

Owing to the large cost involved, and the desirability of widest possible competition, it was decided from the beginning of the studies that plans be prepared and competitive bids be invited for both types. The general design of the bridge was peculiarly adapted for the use of either type.

Bids were called for not only upon the two types of cables, but upon various alternate arrangements, such as cables of each pair placed side by side or one above the other, and cables erected simultaneously or successively, as more fully explained hereinafter, thus giving the bidders wide latitude in applying their ingenuity, experience and facilities in developing the most economical methods of fabrication and erection.

For the two types of cables and the various alternate arrangements unusually elaborate plans and specifications were prepared, covering every detail of the structure.

The question of selection of the type, after bidding, therefore, became essentially one of cost. Wire cables proved to be lowest in cost and were therefore selected.

In accordance with the adopted design there will be two pairs of wire cables, one pair on each side of the floor. The cables of each pair will be erected successively side by side.

Each cable will be three feet in diameter and will be composed of 61 parallel strands of approximately 4½ inches diameter. Each strand will have 434 No. 6 galvanized steel wires of 0.196 inches diameter so that each cable will contain 26,474 wires of an aggregate sectional area of 800 square inches.

The cables will be tightly wrapped with a layer of galvanized wire of 0.148 inch diameter. Each cable will have to sustain a maximum pull of 65,400,000 lbs. or at the average rate of 82,000 lbs. per square inch of metal.

The material of the wires is specified to be manufactured by the open-hearth or the electric furnace process and to have an average minimum tensile strength, when tested after galvanizing, of 225,000 lbs. per square inch. Each of the cables will, therefore, have a strength of about 180,000,000 lbs.

A comparison of the size and strength of these cables with those of a number of other suspension bridges is given in the accompanying table.

Cable Anchorages

The cables will terminate at each end in eyebar anchor chains whose various branches will spread so as to engage, and be embedded in, the requisite mass of rock or masonry which has to resist the pull of the cables. Like the cable proper, these anchor chains are to be erected in four independent units, one for each cable. On the New Jersey side the chains will be anchored in the hard trap rock forming the cliffs. The point of entrance into the rock will be suitably marked architecturally by the masonry portal which forms the entrance to the bridge.

On the New York side the chains are to be anchored in an almost solid block of masonry about 290 feet by 200 feet at its base and 130 feet high resting on bedrock. It will be suitably treated architecturally with stone facing so as to harmonize with the adjoining approach viaduct.

The anchorage of each cable will be composed of 122 lines of eyebars, 10 inches wide by 1¾ to 1⅞ inches thick. They will be of heat-treated carbon

(*Continued on page 34*)

TRUCKS—Automotive type, front axle.

MAIN ROLLERS—Genuine car wheels with Timken roller bearings running on alloy steel shafts.

TRACTION RINGS—One piece forged, high carbon, locomotive steel tires.

DRUM—57 in. x 42 in. with large radius corners. Feed and discharge openings 22 in. *Ample room to handle a three-bag batch of* 1-2½-4.

COUNTERSHAFT—High carbon steel running in Hyatt roller bearings in self-aligning boxes.

GEARS—Cut and running in a bath of oil. Alemite lubrication.

QUICK FEED—Power loader takes full load without crowding and goes up in seven seconds. Automatic knockout on power loader. Overhead shaft carried in self-aligning boxes. Mixer self-sustaining with power loader. No braces required.

CONTROL—All control levers at drum end. Operator sees both power loader and discharge.

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Knowledge Plus Wisdom

(*Continued from page 26*)

fully and without undue haste. "No two things differ more than Hurry and Despatch. Hurry is the mark of a weak mind. Despatch of a strong one."

Beware of desperate steps! The darkest day,
Live till tomorrow, will have passed away.

Learn to keep secrets, your own included, but not like the young lady who made everybody promise that they would not tell. "If a Fool knows a secret, he tells it because he is a Fool; if a Knave knows one, he tells it whenever it is his interest to tell it."

I have quoted quite freely during my remarks, and for three reasons. First, because in the quotations I have used, the authors have presented the ideas in more expressive language than I could frame; second, because I have wished to add their acknowledged authority to my mere statements, and third, because I am very fond of trite yet comprehensive bits of philosophic utterances, that sparkle as they flow. I have the backing of Emerson, for it was he, I believe, who said that the next thing to saying a good thing yourself, is to quote one. I have in most instances not thought it best to interrupt the flow of thought by an allusion to the authors, and, as you know, the quotation marks in my notes are not sounded. This being the case my hearers will doubtless conclude that if I have said anything in any way brilliant it was quoted, and probably they will be right.

We must admit that in rounding out the education of a young engineer we are now leaving a rather large arc unaccounted for and are, perhaps, allowing him to unwittingly run upon the rocks, when with some instruction he might safely keep within the channel. For myself, I feel enthusiastic over the prospect of what might be accomplished. It would be genuinely constructive work. It would not only benefit the student, but would have a favorable influence on the world which he is to serve.

When you graduate engineers go to work, most of you will be in contact with shrewd financiers and keen business and experienced professional men and they may disappoint you by their lack of appreciation for your scholarly attainments. They will inevitably look to see how practical you are. They will admit that your education has put the tools in your hands, but will watch to see how good use you can make of them. It is not always the mechanic who has the most elaborate set of tools that can do the best piece of work. This does not mean that a fine set of tools is not desirable, but it does mean that it is the way the tools are used that counts, and this in turn depends on the industry, the thoughtfulness, the experience and the good judgment of the user.

I am sure that there has never been a time, since the world began, when there was such a crying need for young men of ability, education, character and sound sense, as there is today. You all have the ability and the education or you would not be in the senior class of Technology. Most of you, perhaps all of you, have character, and many of you, doubtless, have a share of sound sense and this latter will grow with use and experience. The world holds good places for those of you who will look patiently and wisely for the one that fits your individual tastes and talents. I presume there are not many among you who are looking forward to the great day when you will become bond salesmen, and I hope my presumption is justified by the facts. I say this because I have heard rumors that quite a number of young men about to graduate from other institutions of the higher learning have such ambitions, if that is the correct name for the feeling.

Men at some time are master of their fates;
The fault — is not in our stars,
But in ourselves, that we are underlings.

I recall a story of a certain business man who went to a great banker and said: "You must have many applications from young men for positions. Kindly send me a dependable man, with whom I can trust my affairs and know that they will be attended to as well as if I had looked after them myself. I will pay him ten thousand dollars a year." The banker replied: "When I find that kind of a man I will pay him twenty-five thousand dollars a year, and more, myself." This illustrates how valuable a *dependable* man is. Rest assured, however, that he must be possessed of both Knowledge and Wisdom.

Our remedies oft in ourselves do lie,
Which we ascribe to heaven; the fated sky
Gives us free scope; only doth backward pull
Our slow designs when we ourselves are dull.

"We should try to succeed by merit, not by favour. He who acquits himself well will always have enough of patrons." To quote from the Egyptian of 4500 years ago: "Let thy thoughts be abundant, let thy mouth be under restraint, and thou shalt argue with the great."

In nature the tremendous forces of the volcano and the earthquake rather tend to elevate and build up, but the daily and hourly attrition of the elements are pulling down what has been before raised up. So it might be with you. The short poem, not notable for literary merit, expresses what I have in mind.

It's not the trees that black the trail,
It's not the ash or pine;
For, if you fall or if you fail,
It was some pesky vine
That tripped you up, that threw you down,
That caught you unaware;
The big things you can walk around
But watch the path for snares.

In life it's not the biggest things
That make the hardest load;
It's not the burden big that brings
Defeat upon the road.
Some fault you hardly knew you had
May hurt more than you think —
Some little habit that is bad
May put you on the blink.

X-Ray Studies of Lime are expected to improve the qualities of lime used in plastering. Dr. Marie Farnsworth of New York University reported recently, to a meeting of the American Chemical Society, that the application of X-Ray crystal analysis to lime may be depended upon to furnish accurate data as to the plasticity of lime samples.

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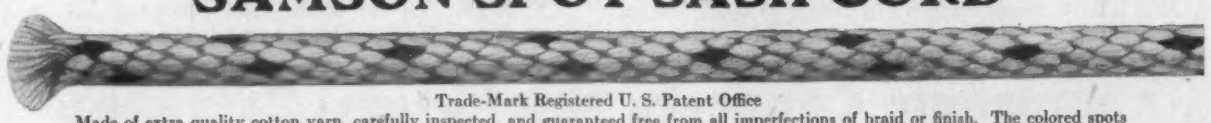

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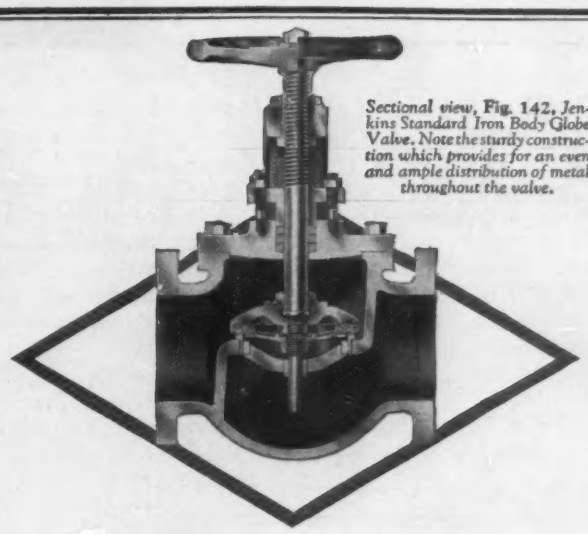

Sectional view, Fig. 142, Jenkins Standard Iron Body Globe Valve. Note the sturdy construction which provides for an even and ample distribution of metal throughout the valve.

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Fig. 715
Jenkins Bronze Fire Angle Valve.

Fig. 338
Jenkins Extra Heavy Iron Body Swing Check Valve, screwed.

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SINCE 1864

Arc Welded Steel Structures

(*Continued from page 16*)

ing length of the edge of the plate was welded intermittently with 2-inch welds on 4-inch centers. This specimen weighed practically the same as the riveted specimen No. 20.

All of these girders were tested by central loading on a bearing plate 1½″ x 5″ x 8″ long placed lengthwise across the top flange of the beam. All of them failed by buckling of the top flange as shown in Figure 12 for No. 21-A.

The previous table gives the pertinent data of tests on the girders. Specimen No. 20–B is the average of the data for two specimens Nos. 20 and 20–A.

The results of these tests are interesting. Specimens No. 19 and No. 20 are made up of duplicate parts, yet the welded girder was slightly lighter and developed eight per cent greater strength than the riveted girder. This is attributed to the fact that welded connections are much more rigid than riveted connections. Welding the heels of the flange angles together and to the edges of the web plate makes the two sets of flange angles practically the equivalent of a solid plate. Specimens No. 21 and No. 21–A indicate that girders which are designed for arc welded fabrication require less material and develop greater strength than similar girders designed for riveted fabrication.

During the tests on these girders none of the welds showed any signs of distress even at the points of maximum stress.

Several other tests were performed. Fatigue tests and shocks tests proved that welded joints will withstand much greater shocks and vibrations than riveted joints. Figures 13 and 14 show an arc-welded structure before and after being subjected to a 70-ton blow. The welded joints showed no sign of failure.

This series of tests demonstrated the following facts:

1. That welded joints can be constructed in such a manner as to develop fully the ultimate strength of the structural members connected.

2. Beams and girders can be connected to columns so as to produce absolute fixation.

3. Lines of beams or girders can be connected so as to provide complete continuity across the supports, whether the supports be girders or columns.

4. That a steel I-beam of given section and length will sustain a far greater load if fixed at its ends by a suitably designed welded joint than is supported by standard riveted connections consisting of top and bottom angles. A 9-inch standard I-beam framed between rigid upright columns 8 feet apart by means of specially designed welded connections sustained a load 25 per cent greater than a beam of the same size and length framed between columns by means of riveted top and bottom angles of ½-inch thickness.

5. A plate girder assembled by welding and consisting of nothing but sheared plates has a far greater bending strength than a riveted plate and angle girder of the same weight, due to better distribution of the steel in the cross section. A 15-inch plate girder assembled by welding and simply supported, on a 14-foot span developed more than 50 per cent greater strength than a riveted plate and angle girder of the same depth and the same weight.

6. That a double angle arc-welded tension member will support 30 per cent more weight than a similar riveted member.

These tests demonstrated the superiority of welded connections in every case where a direct comparison was made and brought out two general facts.

1. That complete continuity of lines of beams can be obtained in welded construction, whereas it is well known that this cannot be done in riveted construction.

2. That in a welded building it is possible to make every joint develop full strength of the main members, whereas in a riveted building many joints are weaker than the members due to the weakening effect of the rivet holes and the weakness of steel angles which have to be used for transmitting

(*Continued on page 40*)

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1407

The Hudson River Bridge

(*Continued from page 28*)

steel and will have an average minimum strength of 85,000 lbs. per square inch and an average minimum yield point of 53,300 lbs. per square inch. The maximum theoretical stress is 30,000 lbs. per square inch.

The Towers and their Foundations

The towers are the main elements which give opportunity to and call for architectural treatment to lend the structure monumental character. In the proposed bridge, the towers are to be of massive construction, which is expressive of their function in supporting the great weight of the suspended structure and is in harmony with the surrounding scenery, more particularly, the massive rock face of the Palisades on the one side and the rocky point of Fort Washington Park on the other. Each tower will be 210 feet by 65 feet at the base and taper slightly towards the top. It will reach to a height of 635 feet above water.

In order to expedite the earliest opening of the bridge, the towers are to be built initially as steel skeletons. After the opening of the bridge to traffic these steel skeletons will be embedded in a concrete casing faced with granite. Although the concrete and granite facing will assist the steel skeleton in carrying the entire load in the completed structure, and will materially increase its strength, it was considered advisable to proportion the steel skeleton so that it could safely carry the entire dead and live load of the completed suspended structure. Steel, concrete and stone will be thoroughly bonded to form a monolithic mass.

The main columns of the towers will be of silicon steel. Carbon steel will be generally used for the bracing and its connections. Silicon steel must show a minimum average yield point of 47,000 lbs. per square inch and a minimum strength of 80,000 lbs. per square inch. The columns are of compact solid-web-section. The maximum stress in the tower columns for a combination of greatest axial and bending stresses from full load of the completed superstructure will not exceed 27,000 lbs. per square inch. For the completed upper deck the stresses will not exceed 22,000 lbs. per square inch and the greatest average axial stress in all columns will not exceed 20,000 lbs. per square inch.

Both towers will rest on solid, hard bedrock. On the New York side, rock is available above water and requires no foundation work except preparation of the surface. On the New Jersey side, rock is reached at a depth of from 35 to 75 feet below water. Each of the two tower legs will rest on a solid base approximately 100 by 90 feet, which is being built within an open cofferdam. This foundation method, although exceptional in size and depth, presents no serious construction problems and permits thorough examination and preparation of the rock surface.

Loads, Wind and Temperature Forces

The dead load of the suspended structure is in the average 39,000 lbs. per linear foot in the center span, and 40,700 lbs. per linear foot in the side spans, or from four to five times the greatest live load which is likely ever to move across the bridge.

For the proportioning of parts of the structure which will be affected by individual load concentrations the heaviest existing vehicles have been assumed, with liberal allowance for possible future increases and for the impact effect produced by vehicles moving at high speed. There are to be

(*Continued on page 38*)

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The Physical Properties of Clay

(Continued from page 11)

to the roughness of the surfaces of the sliding bodies, but to an interaction of their molecules across the plane of contact. The writer, in an attempt to explain the mechanical side of the action of lubricants, came to the conclusion that the molecules of the lubricant are polarized and arranged with their principal axis perpendicularly to the plane of contact. Due to this arrangement of the molecules of the lubricant, the lubricating film should include a plane of weakness comparable to the cleavage planes along which the crystals of micaceous minerals can be split very much more easily than along any other planes. Yet, no convincing argument could be presented for justifying the assumption that the water molecules arrange themselves in the manner characteristic of a lubricant along the surfaces of clay particles while they obviously fail to do so at the points of contact in a sand.

The explanation came unexpectedly, a short time ago, in the reprint of an article mailed to the writer by its author, Professor Goldschmidt, of Oslo, Norway. The paper contained, in addition, the answers to several of the other questions mentioned before this. In his investigations, Professor Goldschmidt started from the known fact that mineral scales are characterized by a layer-lattice structure, that is, everyone of their molecules resembles a little magnetized bar with a positive and a negative pole, the little magnets being arranged in such a manner that the whole crystal body consists of successive layers of positive and negative poles. The cleavage planes, (the planes along which the crystals can be easily split), are distinguished by the fact that they consist of a layer of particularly powerful poles. The active clay particles are nothing else but scale-like particles whose surfaces represent cleavage planes. The poles forming these planes produce electric fields of a considerable intensity. On the other hand, the water molecules, too, re resent small magnets with positive and negative poles. If the water molecules enter the electric field of the cleavage planes, they arrange themselves with their axes perpendicular to the planes, thus fulfilling the condition which, according to the writer's conception, is required to produce a lubricating effect and which, in addition, seems to be required for making the material plastic (Fig. 3). If clay is mixed with a liquid whose molecules are not bipolar, for instance, tetrachlor carbon, the mixture turns out to be nonplastic. The mere fact that the molecules of the water are arranged in a regular manner excludes the possibility that they move and vibrate as freely as do the molecules of the normal water. Hence, within the electric fields of the cleavage planes, the water is virtually in an undercooled state, in agreement with the conceptions of the writer mentioned before.

The Norwegian investigator also succeeded in determining, by combined optical and chemical means, the mineralogical nature and the percentage of scale-like particles contained in Norwegian clays. According to these results, the scale-like particles consist of chlorite, talcum, muscovite, and biotite, and represent about 12 per cent to 27.7 per cent of the total weight. These figures check remarkably well with those which we have obtained at the Massachusetts Institute of Technology by comparing the elastic properties of clays with those of coarse grained sand-mica mixtures.

Two years ago, Ross and Shannon, in Washington, D. C., showed for a rather unusual American clay, the Bentonite, that it consists essentially of minerals which crystallize in micaceous aggregates. Finally, a Russian investigator, in Moscow, found a very simple and ingenious method for experimentally demonstrating that the clay particles arrange themselves perpendicular to the direction in which they travel downward during the process of sedimentation.

As a result of all these investigations we have arrived at fairly clear conceptions of the causes of the physical properties of clay. The plasticity and the low value of internal friction are due to the interaction between very minute scale-like particles of layer-lattice structure and a liquid with bipolar molecules. The great compressibility of the clays, their elasticity, and their high water capacity are produced by a single factor, the presence of scale-like mineral particles, because the clays share this property with dry and coarse grained mixtures of sand and mica. The same is true of the well-known swelling of the clays, because swelling is nothing else but elastic expansion associated with absorption of water, and can be compared with the swelling of a sponge which was first compressed and afterwards allowed to expand under water. Shrinking of clays, too, is purely a mechanical phenomenon combining the effect of the surface tension of the water and high compressibility of the material. The layer-lattice structure enters into the phenomenon of shrinkage only as it seems to cause an increase of the surface tension.

In 1924, the writer published formulas which made it possible to compute the effect of the low permeability of the clay on the settlement of foundations established on the surface of clay deposits. These formulas represent the solution of the quantitative part of the problem. To take advantage of this solution, experimental methods were developed for determining the numerical values of the coefficients which appear in the formulas. Finally, for over a year, efforts are being made in coöperation with the Bureau of Traffic Roads in Washington, D. C., to utilize our knowledge in a broader sense for establishing a soil classification for general engineering purposes.

Thus, by the efforts of individual investigators the nature of this puzzling material was explained. The separate investigators checked and supplemented each other, combining to furnish conclusive information. In each case it was necessary to proceed through complete obscurity. Yet, assisted by conscientious observation, one is able to grasp what is essential. The knowledge of the physical properties of clay will have its effect upon brick making, the ceramic industry, and the attitude of engineers toward this material.

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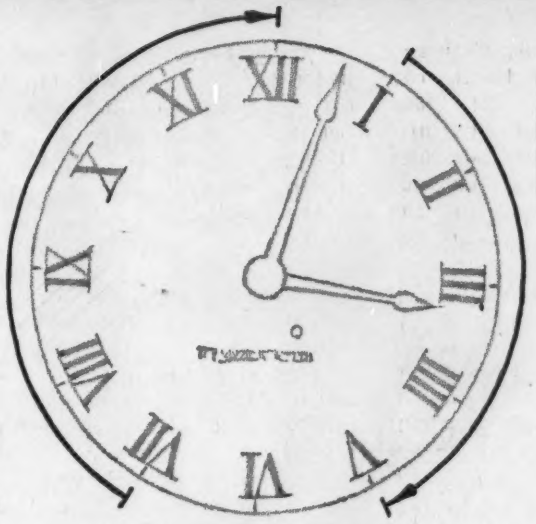

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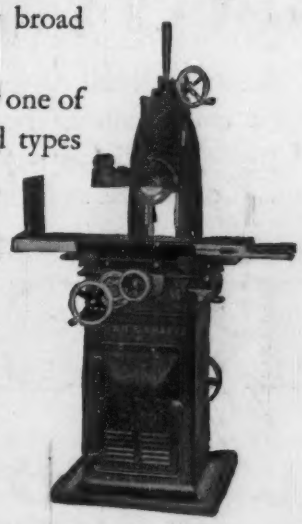

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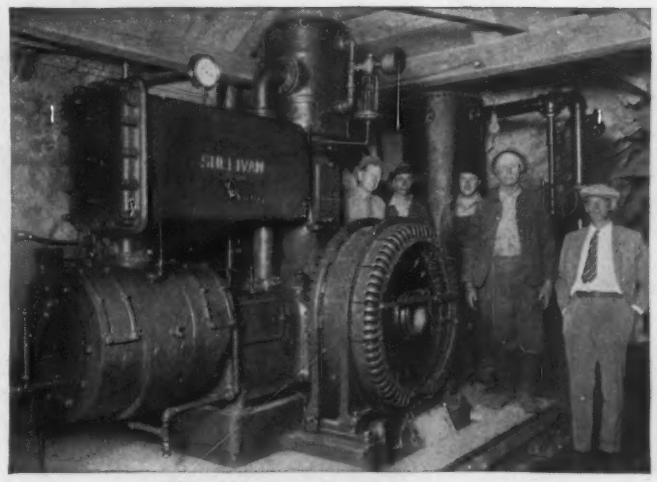

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The Hudson River Bridge

(*Continued from page 34*)

no restrictions as to speed, except such as are advisable for the safety of traffic.

Consistent with increased distribution and variety of load units and their decreasing compound impact effect, the intensity of the assumed load and its impact effect has, by appropriate and convenient formulae, been reduced, both with increasing length of load and with increasing number of load lanes which produce the greatest stresses.

Thus, the roadway flooring has been proportioned for a 25-ton truck with 75 per cent impact, which corresponds to an average of 440 lbs. per square foot of floor space or 4,400 lbs. per linear foot of lane.

For the 60 foot roadway stringers, affected by a single lane of traffic the load with 58 per cent impact is 324 lbs. per square foot or 3,240 lbs. per linear foot of lane. For the roadway floorbeams, which carry two 60 feet panels and eight lanes of vehicles, the load with 17 per cent impact is 140 lbs. per square foot or an average of 1,400 lbs. per linear foot of lane.

For the cables, towers and anchorages, which get their maximum stress from load on the entire bridge and for which impact is neglible the live load has been assumed at 8,000 lbs. per linear foot of bridge. This corresponds to a load composed of 10-ton vehicles spaced on an average 50 feet on centers or 5-ton vehicles spaced 25 feet on centers on all eight roadway lanes on the upper floor and heaviest rapid transit trains, one train length apart on all four electric railway tracks on the lower floor, a load condition which is not likely ever to occur.

For the proportioning of the main lateral or wind bracing along the floor and of the towers a wind pressure of 1,500 lbs. per linear foot of bridge has been assumed. Proper allowance has been made for the fact that a portion of the floor wind force is transmitted to the cables and by the latter carried to the tops of the towers.

A maximum change in temperature of plus or minus 55° from normal has been used as a basis for calculating stresses thereby set up in the structure, and a change of 75° from normal has been assumed in allowing for temperature expansions.

Estimated Cost and Quantities

It is estimated that the bridge will be completed, ready for the initial fourlane roadway and footwalks, but with provision for the construction at any time thereafter of the additional roadways and rapid transit tracks, for approximately sixty million dollars. With an additional expenditure of fifteen million dollars it may be completed to full capacity.

The principal quantities involved in the bridge are as follows:

Excavation	400,000 cu. yds.
Concrete	465,000 cu. yds.
Stone Masonry	57,000 cu. yds.
Steelwork	120,000 tons

Time of Construction

Construction work was started on the New Jersey Tower foundation in May, 1927, and on the rock excavation for the New Jersey Anchorage in June, 1927. On October 13, 1927, contracts were awarded for the entire steel work of the main bridge.

If construction work proceeds as scheduled, the bridge will be open to traffic in 1932, a reasonable length of time for such a structure.

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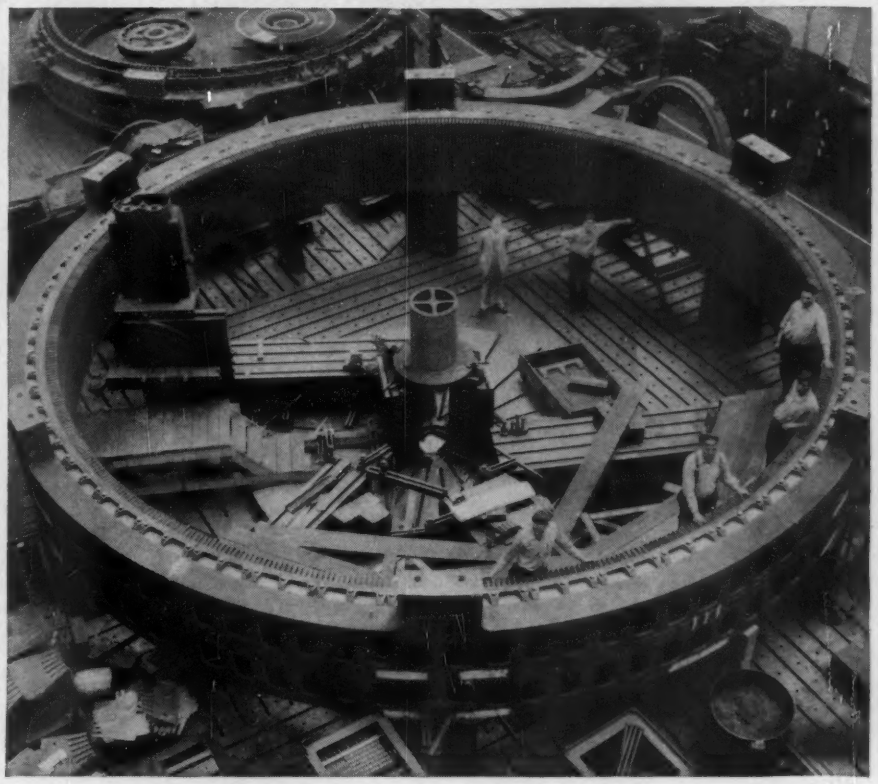

The picture above shows workmen assembling one of the huge Conowingo stators in the Westinghouse Works at East Pittsburgh. The men in the picture will give an idea of the tremendous size of these generators.

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* * *

AT Conowingo, not far from where the Susquehanna River flows into Chesapeake Bay, the Philadelphia Electric Company is erecting a huge dam and power house. This hydro-electric development, one of the largest in the world, has an initial capacity of 281,000 kv-a. in seven units and an ultimate capacity of 440,000 kv-a. The generators, due to their very low operating speed of 81.8 r.p.m., are much larger physically than anything yet built, each machine being approximately 37 feet in diameter and weighing over one million pounds.

Only an organization of the size and resources of Westinghouse can undertake the building of such a large machine. Westinghouse offers great attractions to young men of enterprise and genius because it daily provides facilities and opportunities which smaller companies cannot offer.

Westinghouse

Departmental Notes

(*Continued from page 20*)

to differ from the present one in that a sixth order total equation can be mechanically solved. This, when brought to completion, will again extend the border line of knowledge.

As different pieces of work are brought to completion the results are published in the various scientific publications of America. The Electrical Engineering Department has reprints of these articles bound into bulletin form, these reprints being available to staff members and interested students. At each issue of these bulletins, copies are mailed to institutions of learning and individuals located in all parts of the world. This is a definite tribute to the type of work carried on by the department as the mailing list is only made up of institutions and individuals who have directly solicited the sending of the bulletins.

Students of all departments at Technology are invited to visit the Graduate Research Laboratory of the Electrical Engineering Department. Members of its staff will be glad to explain to visitors items of particular interest to them.

E. G. Bangratz.

Arc Welded Steel Structures

(*Continued from page 32*)

tension between two members at right angles to each other.

In addition to the advantages of arc welding which were brought out by these tests, there are several other obvious advantages that have not been mentioned. For example, the arc-welding process is practically noiseless as compared with the annoying racket of riveting. This fact cannot be overlooked when erecting buildings in down town districts or near hospitals or schools. Welded joints offer a neater structure, and a smoother surface for painting. Most of the steel used in arc-welded buildings can be sent direct from the mill to the field because no drilling is necessary, and furthermore, arc-welded buildings may be designed to eliminate all close cutting. Thus, many of the detail shop drawings and the shop work that are necessary with all riveted structures are eliminated. Another economical advantage of the arc-welding process is that one welder can do the work that formerly required a riveter, a helper, and a blacksmith who heated the rivets and tossed them to the riveter. A new single operator arc-welding machine is shown in Figure 15.

As those of the building profession become better acquainted with the characteristics of the arc-welding process, new applications for it will be found. Arc welding is destined to play an important role in the building programs of the future.

A Cheaper Mechanical Refrigerator. From Norway comes the report that there has recently been constructed along novel lines a new type of mechanical refrigerator. This apparatus, which has attracted considerable attention, is based upon the absorbent power of activated carbon, the cooling substance being ethyl alcohol. A tank, the weight of which is quite small, is completely filled with the activated carbon and a limited amount of alcohol is introduced at a pressure that is considerably below normal. It is claimed by its inventors that a refrigerator of this type, which is suitable for a common household, will require a heating element of only four hundred watts and will use three hundred liters of cooling water every twenty-four hours, and will give under normal conditions a cooling effect corresponding to twenty-two pounds of ice.

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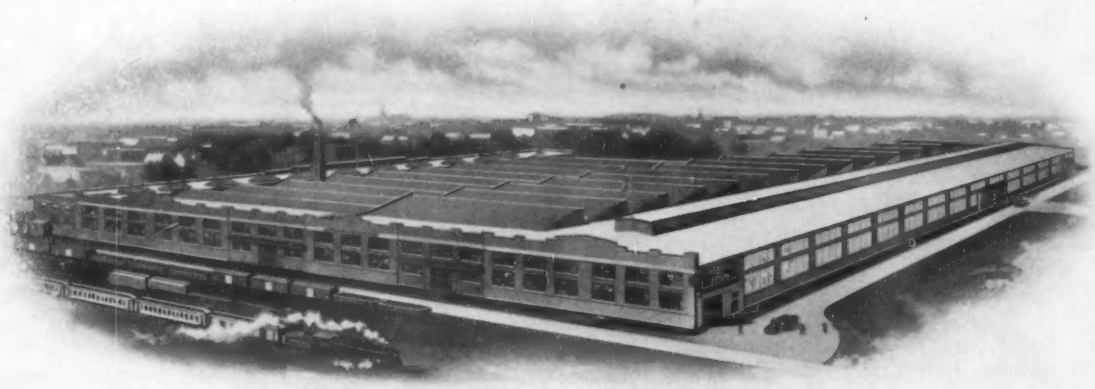

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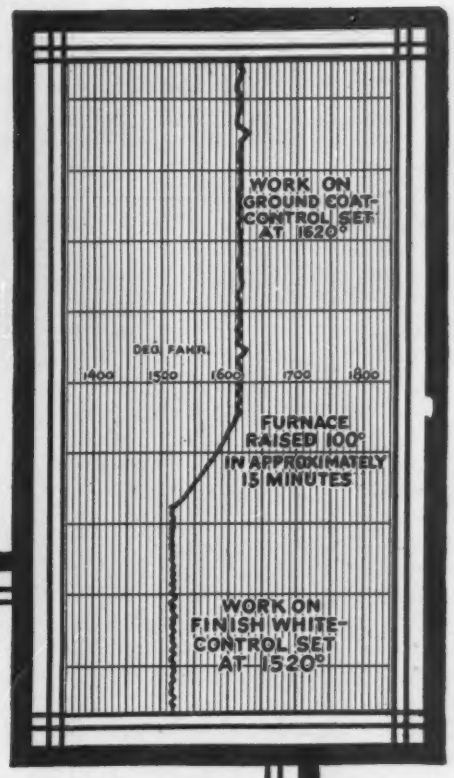


THIS CHART SHOWS

how gas was regulated for two different jobs.

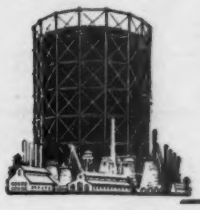
The first job required a temperature of 1520 degrees Fh.

The next job demanded a heat of 1620 degrees Fh.

It took only fifteen minutes to increase the heat 100 degrees.

There is nothing sympathetic or sentimental about an automatic recording instrument. It just registers the facts, and lets them speak for themselves.

The facts revealed by this chart show that Gas Heat gives Control, Speed, Increased Production, Uniform Production, and No Spoilage; all elements that make for economy in operation, and consequently increase in profit.



You would like information concerning the use of gas as a fuel in your own factory, and can easily obtain it by writing to your own gas company, or to

American Gas Association
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YOU CAN DO IT BETTER WITH GAS

Testing Waterwheel Generators

(*Continued from page 13*)

pit by merely bolting them to the steel floor, as would be done in the shops.

Through the center of the pit lid a hole is provided for the rotor shaft to extend upward. The top surface of the lid is faced off to provide for the installation of a vertical-shaft direct-current motor for making the tests. Various motors can be installed, ranging from a few hundred horsepower up to whatever rating is necessary for spinning the big rotors to be built in the future.

A passageway leads down through the wall of the pit to the bottom, and plenty of illumination is provided. The floor of the pit is of slotted steel construction, so that bracing and erecting work can be used in the same way as in the shops. Overhead there is a special crane with two carriages, one carrying a 100-ton hook and the other a 50-ton hook.

In order to carry out the safety precautions to their logical limit, remote control of the driving motor is provided from two supervisory stations. One of these stations is located on the shop floor twenty feet from the mouth of the pit, and consists of a d-c. panel with push-button control, electric speed indicator, and change-over switches to provide dynamic breaking in slowing down. All connections are made by cable carried in ducts set in the concrete.

The second control station is located in an observation building situated some 300 feet from the main test building, to which all circuits are brought by underground cable. Duplicate d-c. control boards are set up here, and tachometers are provided. In addition to these, an adaptation of the oscillograph is employed for vibration recording, which may either be done visually in the usual manner, or made permanent on a continuously moving motion picture film. A telephone circuit is also run to the observation building from the pit, connecting a microphone on the pit wall with head phones at the operator's desk. In this way a close track can be kept of conditions in the pit. Any unusual noise, indicating unbalance of the rotor, or a sudden racket set up by parts flying loose will instantly be heard and will warn the operator to shut down the set immediately.

The plan upon which tests will be conducted is a simple one. After all preparations have been made, the lid of the pit is securely wedged down, and a motor of suitable size installed and coupled to the shaft. The operators then take up their position at the control station in the main building and the test gets underway. First the rotor is set in motion and brought up to its rated speed. After holding this speed for a moment, the motor is shut off and the set allowed to come to rest. The test men then enter the pit and give the rotor a very thorough examination, trying all bolts and fastenings for tightness, and measuring the circumference with a steel tape. Under the centrifugal forces of rotation the structure is bound to expand somewhat, and this is allowed for in the design. Undue expansion serves as a warning that somewhere the metal is not standing up to its work.

If everything proves satisfactory on examination, the rotor is again started up, and an increment of speed is added, the machine running at perhaps 120 per cent of normal. Again the mass is stopped and tests are made. This procedure is repeated several times until the rotor has reached twice normal speed, which is held for a short period, depending upon the contract conditions governing the particular machine under test.

The first run is conducted from the control station on the floor of the main building. When higher than normal speeds are reached, however, the men retire to the observation building, and signs are put up to warn others to keep away from the pit. The energy to be stored in the rotor at double speed is very large and consequently it may take some time after each stop before the desired speed is reached. This gives ample opportunity for discovering any incipient weakness in the whirling mass. When the last run has been made, the power is cut off for good. Dynamic breaking by regeneration may be used if the free coasting time would be unnecessarily long. The tests are usually conducted in the presence of engineers representing the purchaser, and members of the Testing Department. When the purchaser's O. K. has been given, the rotor is dismantled and removed from the pit, later to be set up at the point where it is to go into operation.

The General Electric over-speed test pit is the largest in the world at the present writing, and has been designed and built to provide the greatest possible degree of safety to life and property. It is an interesting side-light on the extraordinary progress which the last two decades have recorded in the generation of electric power, and it serves as an indication of the faith which the manufacturer is placing in the future of his art.

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Diplomatic Diction in Berlin

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Two German diplomats, who had been at the University of Bonn together, met in the foyer of the Hotel Adlon after a separation of some years. One of them had been at a South American capital, one in the Orient.

Eagerly they discussed old times and common memories, and they were still talking excitedly as they started toward the Otis Elevator. When they reached the door, they paused, each wishing to give the other precedence.

"But you must go first, my good friend," one of them was heard to remark. "I'm sure the ride will be a novelty to you after so many years in the East, and I would not think of preceding you."

"On the contrary," answered the other, "I am insisting that you enter first. We lacked some things in the Orient, but the Otis, there as here, is in all the big shops and hotels." "We'd better squeeze in together, then, because South America, too, is well equipped! But wait a moment! You must go first, for I used the Otis on board the steamer every day!" "I, too! I will not be outdone!"

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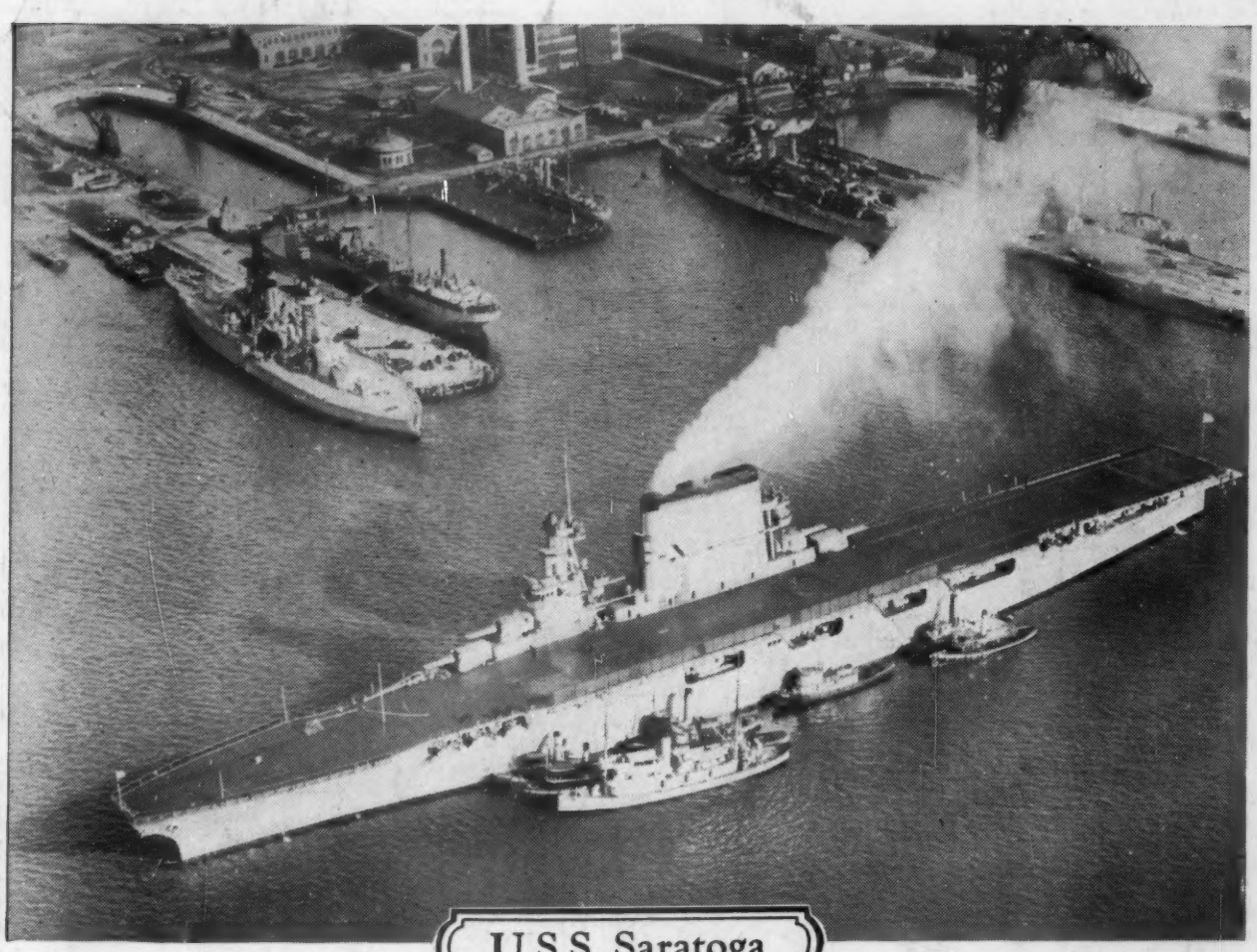

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